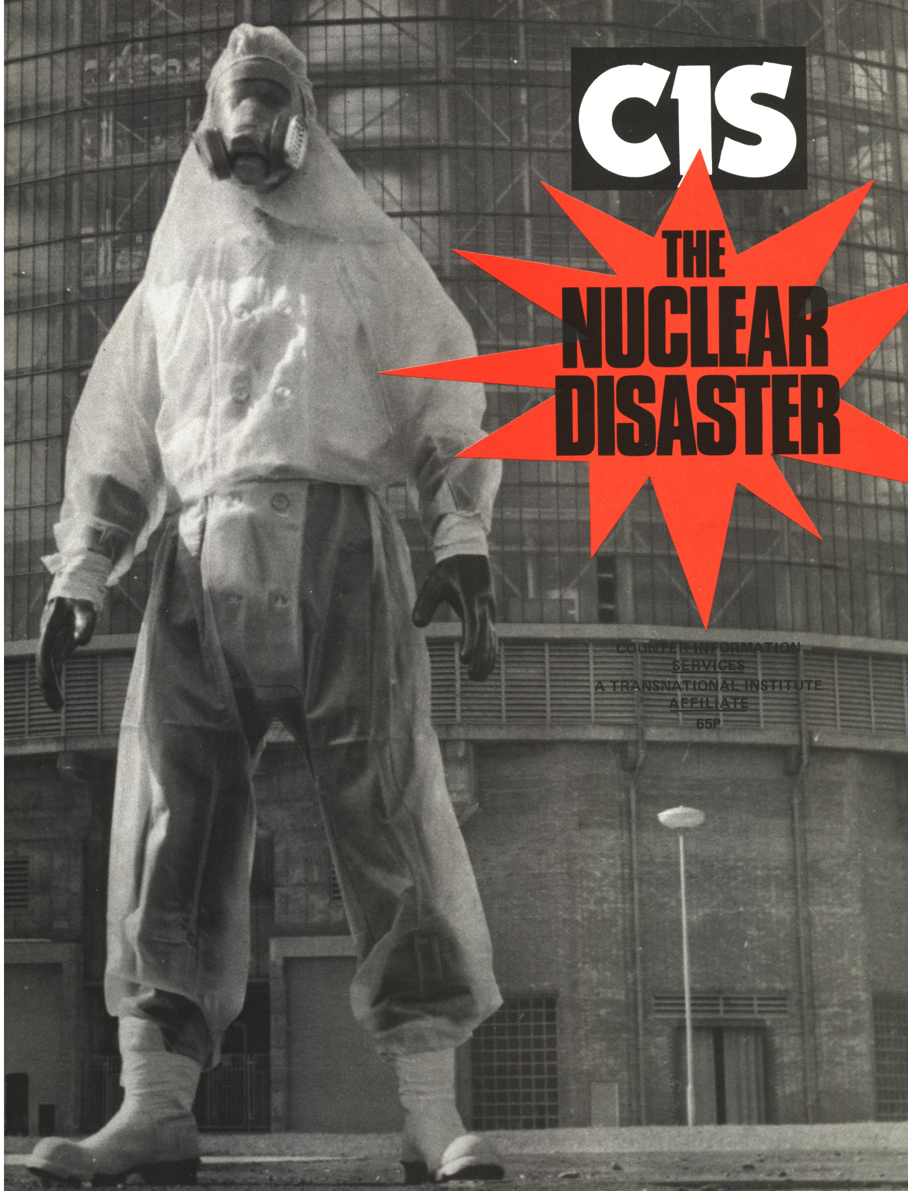

CIS

THE NUCLEAR DISASTER

COUNTER INFORMATION SERVICES
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65P

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Counter Information Services
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Anti-Report No. 22

This report is part of the Transnational Institute programme on the international nuclear industry

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CIS

CIS is a collective of journalists who publish information not covered or collated by the established media. It is their aim to investigate the major social and economic institutions that govern our daily lives in order that the basic facts and assumptions behind them be as widely known as possible. CIS is financed by sales, subscriptions, donations and grants.

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THE NUCLEAR DISASTER

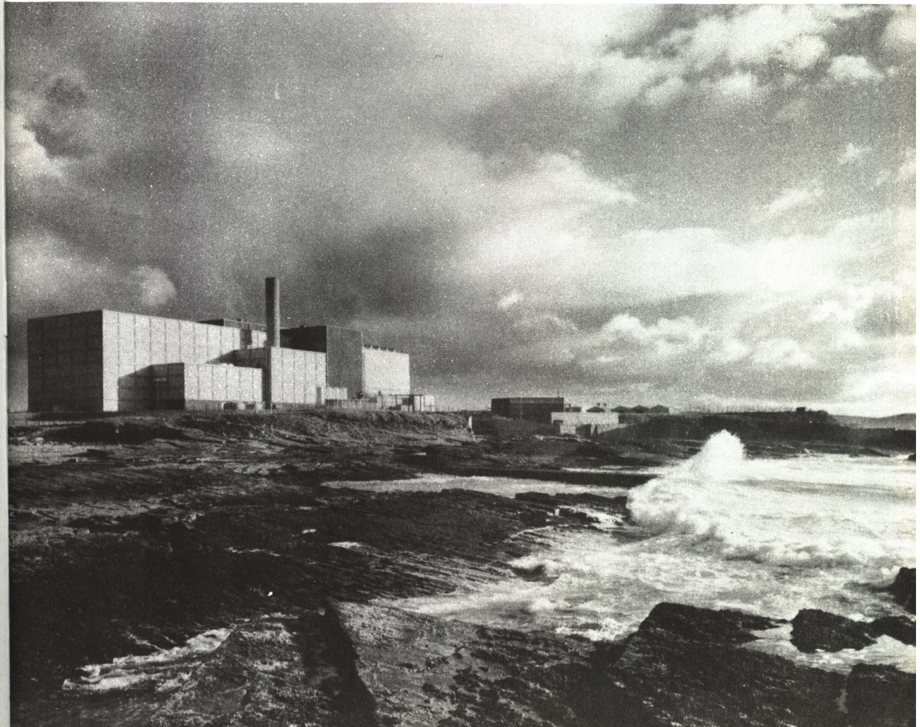
The development of Britain's civil nuclear programme has cost us billions of pounds, and yet there has been a total failure to deliver any of the benefits which were once promised. We were told that nuclear power-generated electricity would be cheap, plentiful and safe. It is none of these things.

Electricity generated by nuclear power is still far more costly than that from other fuels, although by frantically juggling the accounts the generating boards seek to conceal this. The amounts of energy produced by atomic power stations, despite the vast sums invested, is paltry compared to the confident projections and assurances made during the 50s and early 60s — the halcyon days of the atomic dream. Finally, the safety record is wide open to doubt, and the early generation of reactors could never meet present day safety standards.

Behind this appalling record lies an industry in tatters. Staggering from failure to failure, from reorganisation to reorganisation, this dismal mish-mash of private companies and public departments is now totally split over what path to try next. Internal struggles disrupt government plans. Export orders have failed to materialise. In the world market the UK industry is a non-starter.

To date there has been a singular inability to move the debate and arguments over nuclear power beyond the most obvious environmental questions. Vital facts about government errors and inefficiency, the profiteering of private monopolies, the operation of cartels, and the distortion of public information have been glossed over.

The past twenty-five years has been a disastrous history of mismanagement, deceits, failures, and self-preserving secrecy.



THE ROAD TO POWER

Britain's civil nuclear power programme has been an unmitigated disaster. Poor organisation, unworkable designs, delays in construction and failure to export have produced a situation where the nuclear industry has no idea where to go next.

Critical decisions about Britain's energy programme have been made in extreme secrecy, with no information available for informed public discussion. British commitment to civil nuclear energy grew out of an atomic bomb programme of the 1940s and early 1950s, which was developed by successive governments. Under pressure from the United States, the British government introduced unprecedented levels of security vetting for all nuclear employees. **The secrecy surrounding the weapons programme has been carried over into all nuclear information, some of which is sensitive, but most of which is merely embarassing, and of no security significance at all.**

The dynamic of the nuclear industry, particularly in the earlier years, was largely determined by the belief that Britain was in a race with the Americans to build commercial nuclear stations, and that Britain was in the lead. Huge export orders and vast profits were promised. The operation of the world's first nuclear reactor to supply electricity and two early export orders confirmed British beliefs that they were ahead of the opposition, and decisions of a technical nature that would determine options for decades to come were taken with speed as the major deciding factor. As it turned out Britain's apparent lead was an illusion: a case for level pegging could have been made until 1956, but from then on the gap widened. Massive amounts of capital were required to get the industry off the ground, and research and development costs have been paid for with public money. The UK nuclear industry has been encouraged to call upon government money like no other enterprise past or present. These commercial considerations have provided the industry with another basis for sheltering behind a veil of secrecy.

Origins

The origins of the British nuclear industry are to be found in 1946, when it was decided that Britain should have a nuclear defence force and that the government should build the factories required to produce plutonium and uranium.

The Ministry of Supply chose the air cooled reactor, rather than the water-cooled system adopted by the Americans, and built the prototypes at Windscale. This led to the gas-cooled reactors at Calder Hall, which were built to produce plutonium for defence purposes, and also as a prototype for the first nuclear power stations.

The AEA

In 1954, during the construction of the Calder Hall reactors, but before the decision to proceed with a civil nuclear programme was taken, the Atomic Energy Authority (AEA) was formed. The Authority, a public corporation, inherited the Ministry of Supply's responsibility for research and development in the nuclear sphere. There was no attempt to disentangle military and civilian responsibilities, and the entire nuclear defence programme and embryonic civil nuclear power programme lay in the Authority's hands.

The AEA is the sole source of technical expertise on nuclear affairs. It is the advisor to the Minister responsible for nuclear energy decisions. It depends for its very existence on the nuclear programme. As the industry has become steadily more monolithic over the past two decades, the Authority's influence has increased with catastrophic effects.

At the same time, in 1954 the Conservative government decided that design and construction of nuclear power stations would be carried out by British firms already involved in building coal and oil fired power stations, and that nuclear power stations would be owned and operated by the electricity generating boards. To achieve this, four design and construction groups were formed in 1954 by associating boilermakers, electrical manufacturers, engineering and civil engineering firms. Under pressure from the industry a fifth consortium was formed in 1956. The AEA remained in control of making and reprocessing nuclear fuel, and of the research and development of new prototype power stations.

In 1955, a decision was taken which was to have profound effect on the whole development of nuclear power in Britain. Fearful of losing its apparent lead to the Americans the AEA decided to conserve resources and concentrate its development effort on a narrow front – the gas-cooled graphite reactors of the type that were already installed at Windscale and Calder Hall.

At the same time, work continued on the fast breeder reactor which was started in 1953 as a longer term project. Fast reactors not only burn plutonium produced as waste by thermal reactors, but can also produce it as fuel for other reactors.

In 1955 the Ten Year Magnox programme was launched. Based on the operation of the one prototype at Calder Hall, no less than 12 stations were to be ordered, with a total capacity of 1,500 to 2,000MW. This was increased in the aftermath of the Suez crisis in 1957 to 5,000MW. But by late 1957, this enthusiasm was waning and under pressure from the Central Electricity Generating Board the programme was curtailed.

Eventually the programme amounted to nine stations. Each was of a unique design, some radically different from the others. They were built by five different consortia of private companies. The first two produced electricity in 1962, while the last, Wylfa, was only commissioned in 1971 after major technical difficulties. By that time all save one of the stations had been derated (reduced power output) by 10% to 20%, largely because of unforeseen corrosion problems in the reactor. Early on, two Magnox reactors were sold overseas, but since 1959, despite intense effort, not a single British reactor has been exported . . .

It is now universally agreed in the United Kingdom that it was incautious to proceed with Magnox from a first off prototype to a full scale programme of nuclear stations. It is widely, though not universally, accepted that the AEA decision to concentrate exclusively on the gas/graphite type of reactor was a mistake. It has been progressively established, and acknowledged, that the 1955-57 forecasts of low 'competitive' costs were based on wrong economic, technical and commercial assumptions.

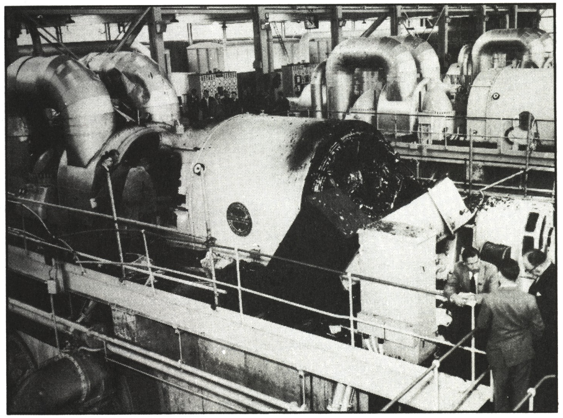
Export Failure

Throughout the history of the nuclear programme problems have arisen because of the organisation and structure of the industry. The government's main concern, throughout the 1950s, was to encourage 'competition', among the consortia, despite the relative technical and financial weakness of some of the companies involved. During the Magnox programme it was possible, for a while, to sustain five companies, since the initial size of reactor capacities was small and the work could be divided up. But by 1960 it was clear that Magnox would not give rise to a steady flow of export orders, that reactor size was increasing and that the Magnox programme was slowing down. Five consortia were clearly far too many.

Keystone

The Queen opens Calder Hall – Britain's first nuclear power station.

Wreckage landed outside the plant when a turbine blew up at Calder Hall.



Keystone

As a result the five groups were reduced to three in 1960. By 1965 the situation was critical. No export breakthrough had been achieved and the sharing of a limited number of design staff meant that each consortium was too weak in its design engineering capacity to make successful reactors on a commercial scale.

The AGR Programme

In the early 1960s it seemed probable that the Advanced Gas Cooled Reactor (AGR) would be Britain's choice for the second generation of reactors. Construction of an AGR prototype had begun in 1958, four years before the first Magnox commercial station was producing electricity, and only two years after Calder Hall, the Magnox prototype, had produced electricity. Power was first produced by the AGR prototype in December 1962.

The AGR is a gas/graphite reactor in direct line of development from the Magnox but with a much more complex design. According to its advocates it promised considerable savings in generating costs. However, late in 1963 General Electric in the

US announced that they had secured a contract to build a water-cooled reactor (LWR) which promised to generate electricity very competitively. The CEGB was strongly attracted, and the government decided that it should compare the costs of the two systems, the AGR and the American LWR, before ordering its next station – Dungeness B.

Political Choice

Of the three consortia in existence at the time, the two strongest were Babcock-English Electric and the Nuclear Power Group, each of which had a licence to build American LWR systems. Both these consortia disliked the AGR design, judged it uncompetitive and were encouraged by the CEGB to study the American design and submit tenders. Atomic Power Constructions (APC) was the third and financially weakest of the consortia. Because of its financial position, APC withdrew its initial bid for Dungeness B, and it seemed that it would take no further interest in tendering.

The AEA needed a costed design study of the AGR for its own use in compiling reports on the development potential of the system. With APC apparently out of the running for Dungeness B, the Authority entered into negotiations with them to enlist their assistance with this work. At the last minute, this costed design study formed the heart of a brief APC bid for Dungeness B.

The CEGB and the AEA then jointly conducted an appraisal of the various bids. The CEGB as purchaser had more representatives in the appraising team than the Authority, and the final decision on reactor choice was made by the CEGB.

The result was, the government announced, a triumphant vindication of British nuclear development. Fred Lee, Minister of Power in 1965, told the House of Commons: "We have made the greatest breakthrough of all time . . . We have hit the jackpot this time". These must rank among the most absurd of all ministerial pronouncements. The news had a good press, and detailed substantiation of the claims published by the CEGB was accepted as evidence and used for pretentious forecasts and estimates. The advantage in cost claimed in the appraisal was 0.01p per unit, well within the statistical margin of error. The comparison involved great hazards and some bias. The design of the 600MW AGR was extrapolated from a 30MW prototype, which gave much greater room for error than the extrapolation from a 200MW LWR. Recent design improvements in the LWR accepted by American utilities were rejected as unproven by the CEGB, while more radical and untested changes for the AGR were accepted. The appraisal contained inadequate data on fuel cycle costs, and assumed that a 600MW turbo alternator, of which none had yet been made in Britain, would stop for maintenance only once every two years, contrary to all experience.

Despite the fact that APC's bid was 10% higher than the Nuclear Power Group's bid for a LWR and that it was based only on a sketch design, it was accepted for Dungeness B. AGRs were to form the second nuclear power programme.

It is now clear that the government lacked the economic and technical grounds on which to question the wisdom of the commitment to the AGR, but since it was British technology there were strong political reasons for selecting it. According to Sir Arthur Hawkins, Chairman of the CEGB, the AEA had put the strongest pressure on them to choose the AGR.

Strained Relations

Relations between the Authority and the CEGB were quite strained at this point. The CEGB had actually told the consortia that it considered the AGR unsuitable for Dungeness B, and it was also annoyed that there had been no consultation over the AEA's decision to build a prototype Steam Generating Heavy Water Reactor (SGHWR) as a fall-back reactor type for the future. The split was sufficiently severe for Quintin Hogg, the Minister at the time, to set up an inter-departmental committee to 'reconcile the differences'. At the end of 1964, Sir Christopher Hinton, who had been associated with the nuclear programme from its birth, resigned as chairman of the CEGB at his own request.

In October 1965 the size of the second nuclear power programme was increased from 5,000MW to nearly 8,000MW. This called for the commissioning of one new AGR a year between 1970 and 1975, meaning that nearly all the reactors would be under construction before a single commercial one had been completed. In the event reductions in anticipated demand for electricity meant that only five stations were ordered, but this still constituted a large programme of more than 6,000MW.

Early in 1967, the Nuclear Power Group secured a contract for the AGR at Hinckley Point B, and later for Hunterston B in the South of Scotland. The other consortium, the Babcock, English Electric Nuclear Ltd, had the contracts for Hartlepool and Heysham.

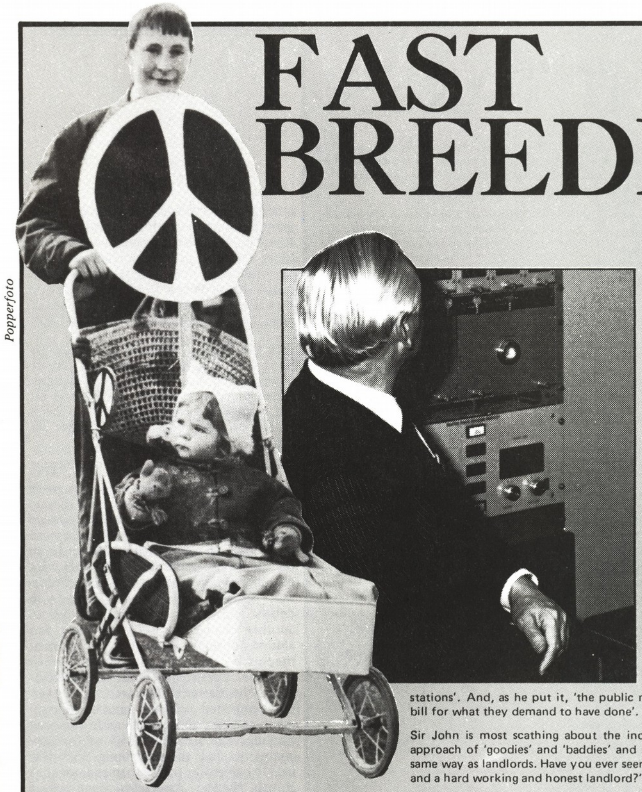
Dungeness

By late 1967 there were major problems at Dungeness B. Given the untested and sketchy design on which the original decision was based, this was not surprising. APC just did not have the managerial and technical resources to cope with the project, and in 1969 it collapsed. The CEGB was forced to take over all the costs of the venture, and the English Electric Group, by now reconstituted as the British Nuclear Design and Construction Ltd, took over the management. Dungeness B was due for completion in 1970. That date has been pushed further and further back. It now stands at 1981.

Hinckley Point B, the next AGR, should have been the effective prototype for the other reactors, but this has never happened. Each of the three consortia secured AGR contracts with very different designs. By 1970 as planned over 6,000MW of AGR capacity was under construction though no commercial scale reactor was near to completion. The differences in designs meant that effectively three commercial scale prototypes were being built.

Two of the AGRs, Hinckley Point and Hunterstone B, finally produced electricity in February 1976, four years behind schedule and nine years after contracts were issued. Those at Hartlepool and Heysham, begun in 1968 and 1970 respectively, are now not expected to supply electricity until 1981. All have had to undergo considerable modific-

FAST BREEDERS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Sir John Hill is Chairman of the Atomic Energy Authority. In this position he is responsible for a body which, in its short life, has already managed to consume over £4billion of public money at today's prices. It is a body that also oversees the development of perhaps the most dangerous of all today's technologies.

Sir John's public words reflect this responsibility. His judgement of the 'Appraisal' that led to the disastrous Dungeness B decision was that it was a 'meticulously fair and proper analysis'. His comment on the question of radioactive waste from nuclear reactors was equally incisive: 'we underestimated the problem'.

Nevertheless, Sir John's acuteness on long-term nuclear strategy is well known. The AEA's largest single programme is development of the fast breeder reactor. As Sir John put it, 'the purpose of developing the fast reactor is to give this country the option, the freedom and the ability to build a series of fast reactor power stations'. And, as he put it, 'the public must recognise that they pick up the bill for what they demand to have done'.

Sir John is most scathing about the industry's critics. 'They use the simple approach of 'goodies' and 'baddies' and the nuclear industry is treated in the same way as landlords. Have you ever seen a programme about a wicked tenant and a hard working and honest landlord?'

ation during construction. There have already been failures at Hinckley Point and Hunterston B. At Hinckley Point a water pipe fractured, extensively flooding the pumphouse and cutting supplies of cooling water to the reactors. At Hunterston B a suckback of sea water early in 1978 deposited salt inside the reactor pressure vessel. The station was put totally out of action, and repairs will take at least a year and cost a fortune.

The delays and changes during construction forced the costs of the AGR programme dramatically upwards – the original estimates have been exceeded by at least 300%. By 1973, Hawkins of the CEGB admitted to a Parliamentary Select Committee that the system was expensive, inherently difficult and unexportable. The whole edifice, built on the Conservative decisions of 1953-55, reinforced by the Dungeness B decision of the Labour government in 1964-5, had fallen like a house of cards.

Assurance

One of the most surprising aspects of the 1965 AGR decision was the size of the commitment to a technology which was unproved. There were no special reasons for the government to commit itself to such a large programme on the grounds of explicit national fuel policy: no major threat to coal or oil supplies was foreseen.

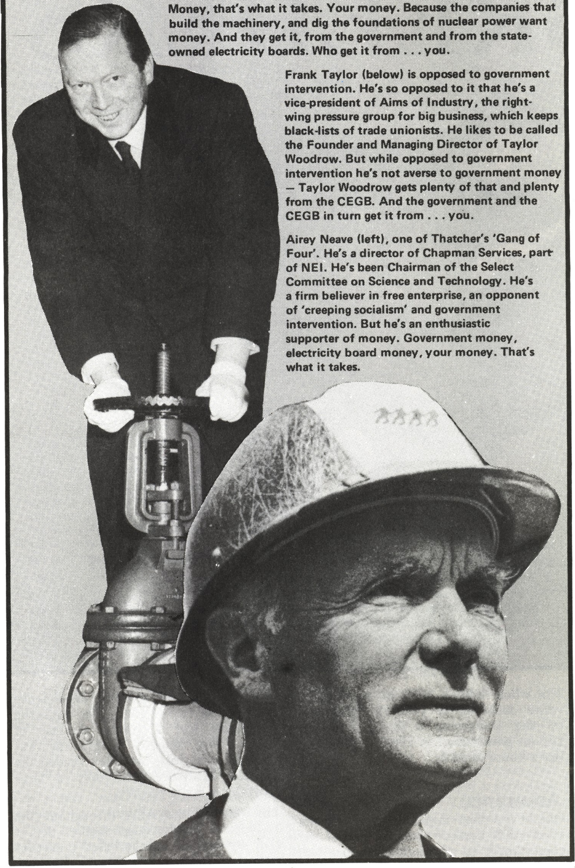
One of the main official reasons for the decision was the government's desire to maintain competition among the private consortia, thereby avoiding dependence upon one or two of them. The consortia themselves had a vested interest of course. The Magnox programme was drawing to a close, and they needed the financial assurance that only a large programme could provide.

The role of the AEA throughout the episode is highly questionable. Senior civil servants in science based ministries were saying in 1964 that a decision against the AGR would be seen as ending the role of the AEA in the civil nuclear programme. Certainly the Authority chose the AGR, developed it in isolation, and promoted it strongly for Dungeness B and the whole of the second nuclear power programme.

It is now clear that the whole strategy of

development as advised and organised by the AEA was wrong. The entire nuclear industry has been undermined by the failure of the AGR programme: the express intention of building up an industry capable of constructing nuclear plants in numbers when they are needed has not been fulfilled.

WHAT IT TAKES



Keystone

Money, that's what it takes. Your money. Because the companies that build the machinery, and dig the foundations of nuclear power want money. And they get it, from the government and from the state-owned electricity boards. Who get it from . . . you.

Frank Taylor (below) is opposed to government intervention. He's so opposed to it that he's a vice-president of Aims of Industry, the right-wing pressure group for big business, which keeps black-lists of trade unionists. He likes to be called the Founder and Managing Director of Taylor Woodrow. But while opposed to government intervention he's not averse to government money – Taylor Woodrow gets plenty of that and plenty from the CEGB. And the government and the CEGB in turn get it from . . . you.

Airey Neave (left), one of Thatcher's 'Gang of Four'. He's a director of Chapman Services, part of NEI. He's been Chairman of the Select Committee on Science and Technology. He's a firm believer in free enterprise, an opponent of 'creeping socialism' and government intervention. But he's an enthusiastic supporter of money. Government money, electricity board money, your money. That's what it takes.

Centralisation

Parallel to the deepening AGR crisis ran the continuing effort by the government to find a workable form of organisation for the private companies. Agitation for a single design and construction company for nuclear reactors started in 1964. It arose from the disappointments, frictions and struggle of the late 1950s and early 1960s, with orders for Magnox plants being reduced, no export orders in sight, and the selection of the AGR being threatened by the US designed LWR.

With the choice of the AGR for Dungeness B, it was widely expected that export orders could be obtained immediately. Absence of such orders was blamed on the number of consortia, said to be a source of high costs and a damper on exports.

In 1968-9 one of the consortia, APC, went bankrupt, and the other two were reconstituted: the Nuclear Power Group Ltd and the British Nuclear Design Construction Ltd. The AEA became a participant in each, with a representative on the boards, and Authority staff were absorbed in the new companies. Persistent failures in AGR development, with delays and losses building up, led to another change in 1973. As there was almost universal support for a national monopoly, the Tory government formed a single design and construction company, the National Nuclear Corporation. GEC provided half the capital, management services and considerable financial backing. The AEA had 15% of the new company, and the remaining 35% was held by a group of companies known as British Nuclear Associates made up of Babcock & Wilcox, Northern Engineering, McAlpine, Taylor Woodrow, Whessoe, Dickinson Robinson, and Strachan & Henshaw.

Divisions over reactor choice have since led GEC to reduce its stake to 30%, with the AEA taking up these shares to give it a 35% stake.

Late in 1970 Heysham, the last of the AGR stations, was ordered. At the same time, the new Tory government commissioned the Vinter inquiry to look into the choice of reactor systems, and for the whole of 1971 all decisions were held up pending the outcome. Vinter reported in early 1972 – but in secret. Even the Parliamentary Select Committee was denied access. Although to this day the contents remain secret, it appears Vinter came to no decisive conclusion.

By 1973, the CEGB was ready to buy more stations, and after long discussion chose the Westinghouse designed LWR. GEC agreed with this policy, seeing LWRs as the source of future profit, and set about planning new factories and a cooperation deal with the French. But still no ministerial decision was reached. The South of Scotland Electricity Board favoured the SGHWR. Advisory Boards and Select Committee met to consider the evidence, but it was not till July 1974 that Eric Varley, Labour's new Energy Secretary announced his decision. The British designed SGHWR had been chosen for the next generation of nuclear power stations, in preference to the LWR.

It was clearly a political decision, and left a split between the CEGB and GEC on one side, and the rest of the industry on the other. The Select Committee, in particular, had been intensely hostile to advocates of the LWR system, and had actively sought out reasons why it should not be chosen.

Internal Struggles

By 1976, three SGHWRs were still being designed, none had been ordered and pressure was building up. In November 1976, the Central Policy Review Staff (Think Tank) published a report on the Future of the British Power Plant Manufacturing Industry. This stated that the UK did not have a nuclear system with export potential. In July 1977, the National Nuclear Corporation brought out its own report on reactor systems. This recommended that the LWR be adopted, and that there should be no further orders for the AGR. It saw the LWR system as the only one offering the possibility of building up the UK industry to realise any export potential, or indeed to cope with large domestic orders in the 1990s.

Once again, deep splits were revealed within the industry. It is believed that a division existed within the cabinet, with Callaghan in favour of a firm commitment to build a LWR as well as a few more AGRs. On the other hand, Benn seems to think that the AGR is the only system that is capable of achieving public acceptance.

There also appeared to be a split within the Department of Energy. Benn's Junior Minister, John Cunningham, and various technical advisers were urging commitment to a positive nuclear power programme that could include AGRs, LWRs and the first commercial fast reactor. Benn himself was making public statements about the uncertainty of energy forecasts and the potential for conservation. Meanwhile GEC were still advocating the LWR but were prepared to accept a compromise provided that there was no question about the commitment to start building at least one LWR in the early 1980s.

The Electricity Council, chaired by Frank Tombs, which had previously favoured the SGHWR, was now claiming that an updated AGR was a perfectly suitable choice. By contrast Glynn England – chairman of the CEGB – wanted to proceed with the AGR-LWR mixed programme.

The eventual decision announced by Benn was to order two additional AGRs and to abandon the commercialisation of the SGHWR, which had been selected as the preferred system in 1974. There is some confusion about the parallel commitment to build at least one LWR. Benn stated that, provided design work is satisfactorily completed and safety clearances met, a LWR will be ordered, but that a start on site could not be made before 1982. This has left him the option of reactivating the debate on the LWR in two years time. To judge from GEC's reaction, their belief is that the LWR will not materialise.

Disarray

There have since been renewed calls for yet another change in the structure of the industry. GEC is concerned primarily with growth and that will not be found in the UK nuclear industry while it adheres to AGR. So GEC prefers to concentrate its nuclear activities on co-operation with Westinghouse outside the UK. Other participants are simply concerned to keep a finger in what are still large public contracts, all with a guaranteed profit now that the National Nuclear Corporation with its large public stake acts as a main contractor.

Benn has made it clear that his personal preference is for a company structure similar to that of BP in which the Government has a 51% stake. GEC states that it wants to give up its management control and to relinquish more of its shareholding in the National Nuclear Corporation.

On the other side shareholders led by Babcock and Wilcox have been demanding an end to GEC control. There is also a certain amount of disarray amongst these other shareholders, caused by the recent breakdown of merger talks between the boiler makers, Northern Engineering Industries (NEI) and Babcock & Wilcox. The NEI group was established only last year by the merger of Clarke Chapman and Reyrolle Parsons. This followed failure in a parallel attempt to merge Reyrolle's and GEC's turbogenerator interests.

The CEGB has told Benn that these conflicts cannot continue now that £1,300m worth of orders are in the pipeline, and there is no prospect that formal design contracts for the new AGRs will be placed by the CEGB and the SSEB until a new company structure is formed.

With the industry in its present disarray, it seems unlikely that future decisions about the nuclear programme will be any less disastrous than those of the past 30 years.

GEC : BUYING INTO A NUCLEAR WORLD

GEC has been involved in the nuclear industry in Britain for many years now. During the mergers of the late 1960s, GEC (with the active help of Harold Wilson's Industrial Reorganisation Corporation) absorbed two major competitors, AEI and English Electric. Since then the company has come to totally dominate the UK electrical industry.

Its sheer size as the largest private employer in the UK gives the company considerable influence in both industrial and political circles. More than that, GEC has established a reputation for efficiency in British industry: its brand of management is seen as setting the example for the regeneration of the economy.

That is why, when it came to establishing a single design and construction company for the nuclear industry, the government insisted on putting GEC into the driving seat. The structure created for the National Nuclear Corporation (NNC) gave GEC the major stake. Peter Walker, the responsible Secretary of State said: "50% of the share capital would be held by GEC whose international standing and financial and managerial strength will be most valuable . . . GEC would play a supervisory role on a basis agreed with the main board of the new company and would be paid for services provided." (22.3.74)

Sir Arnold Weinstock, head of GEC, was set to become 'the country's nuclear generalissimo' as *The Times* put it, largely because of the reputation he acquired for rescuing GEC-AEI-EE. But what does the record at GEC show?

Consider the period between 1970 and 1978. On the surface sales, profits, fixed assets: buildings, plant machinery and tially. Sales rose 162%, fixed assets 84% and profits an enormous 493%. But when the figures are adjusted to take account of inflation, the picture is very different. In real terms sales have dropped slightly – despite the rapid price rises to secure the extra profits. Profits have risen a sizeable 122%, but at the same time fixed assets: buildings, plant machinery and equipment, have fallen no less than 31%, almost a third. Cash in hand rose from a deficit to £617million, more than the entire fixed assets of the company.

GEC – the public record

	1970 £m	1978 £m	Increase %
Sales	891	2,343	162
Fixed Assets	173	318	84
Profits	58	344	493
Net cash	(55)	617	–

This looks very healthy and certainly Weinstock's many admirers at Westminster and in the City think so. When you look at the figures adjusted for inflation, on the other hand, the picture is very different.

GEC – the truth **All figures at 1978 prices**

	1970 £m	1978 £m	Increase %
Sales	2,375	2,343	–1.3
Fixed Assets	461	318	–31.0
Profits	155	344	+122
Net cash	(146)	617	–

In real terms, all that Weinstock has achieved is a massive hike in profits and cash in hand. These profits have been won directly at the expense of GEC's workforce. In 1970, GEC employed 206,000 people in the UK. By 1978, this was down to 156,000. Against the background of a doubling of profits in real terms, jobs were cut by one-quarter.

Cash Mountain

Arnold Weinstock himself has done very well. True, in 1976-7, he held his remuneration down to £50,000 or so, not counting perks. He also held a 'beneficial interest' in 2,779,441 GEC shares – worth some £8,838,600 today. These earned a gross income equivalent to £153,703 in dividends alone. On top of all this was the ingenious capital reconstruction scheme, whereby shareholders received a handsome bonus in the form of capital notes. Weinstock's 'beneficial interest' benefited to the tune of £903,200 worth. In the year that unemployment topped the 1½million mark, Weinstock's income (both direct and beneficial) from GEC was equivalent to more than £1.1million. What's more, most of that 'income' would only be taxable at the capital gains rate of 30%.

The reality is that Weinstock's achievement at GEC has been a disservice to the British economy. True, it has meant more profits for management and shareholders, and it has added to the cash floating around the finance markets of the City of London and the rest of the world. But its real effect has been to reduce employment and deplete Britain's manufacturing base. Hardly the stuff that industrial regeneration is made of. Yet this is the company and the man that are supposed to bring about the regeneration of the British nuclear industry.

GEC stresses immediate profitability above all else. In this it is unusual. This is not to say that other large companies are any less concerned about profitability, but many companies are prepared to invest in what may initially be comparatively unprofitable operations, confident that they may reap enormous benefits later. The whole history of GEC under Weinstock points to a different approach. GEC wants to keep its cash mountains intact, and to keep the profits rolling in. That means concentrating on boosting immediate profits, and, if investment is absolutely necessary, doing so at a minimal level.

Looking at GEC's interest in the nuclear industry in the light of this provides a new perspective. Since 1974, when GEC was put in charge of the NNC, a series of skirmishes has been fought over the choice of system for future reactors. The GEC faction has been pushing hard for the adoption of the Pressurised Water Reactor (PWR) – one of the American Light Water Reactor systems. Decisions have however continually gone against the PWR, and GEC's reaction has been to threaten withdrawal. In 1976, the company reduced its shareholding in the NNC from 50% to 30% forcing the government, through the Atomic Energy Authority, to take up the 20% shareholding involved.

GEC Withdraws

In January 1978, Tony Benn, Secretary of State for Energy, announced that despite heavy lobbying for the PWR, two more AGRs would be ordered. He made an ambiguous commitment to order a PWR later, providing safety criteria and

feasibility studies proved acceptable. GEC evidently regarded this as an attempt to avoid the decision on the PWR, and had no confidence that it would ever materialise. In an attempt to keep up the pressure for the PWR, they asked for their shareholding to be reduced again, this time to 15%. The company also 'informed H.M. Government that, at a time convenient, it wishes to end the contract under which it exercises a supervisory role over the activities of the National Nuclear Corporation.' (Annual Report 1978)

Why should GEC withdraw from contracts that are profitable and involve no significant risk? Participation in the NNC does not, and will not, generate large profits: these will come from the contracts to build the nuclear stations themselves. On the other hand, participation does require some management effort on GEC's part – effort which in the company's view could be more profitably deployed elsewhere. While the UK remains committed to the AGR, a large nuclear construction programme is unlikely, and what few orders there are will go to GEC anyway. There are no prospects whatsoever of foreign sales of the AGR.

Sir Arnold Weinstock – Managing Director of GEC.

Keystone

The PWR, on the other hand, has far more potential for a company like GEC. It is cheaper to build; it is the most widely accepted system, and has been adopted by energy companies all over the world; a large part of the costs of research, development and testing have already been met. A greater proportion of the PWR can be built in factories rather than on site than is the case with the AGR. This means more control in terms of quality and cost, and also that a larger share of the business will go to manufacturing companies like GEC rather than construction companies.

There is a massive amount of information available on the PWR, and many stations already running. This could allow rapid development of the PWR in Britain. That is what GEC wants, because then there really would be large profits to reap. More than that, it would provide a strong base from which to enter the international market for complete nuclear power stations or components.

The International Market

Although in Britain the nuclear power programme has declined to a fitful tickover, across the globe huge amounts of capital are still being pumped into nuclear energy. North and South, East and West, despite the recession, stations are still being ordered and built.

Now that the AGR has effectively been ruled out by the failure of the UK programme, there remain only two viable systems on the international market. These are the Canadian CANDU heavy water reactor and the American (and also Russian) Light Water Reactor. Although the CANDU has been sold internationally (an order was placed by Romania as recently as October 1978), the clear market leader is the American LWR. Two companies are in competition with different designs: Westinghouse, with a pressurised light water reactor (PWR) and General Electric (no relation to GEC) with a boiling light water reactor (BWR). So far, Westinghouse's sales have easily outstripped those of General Electric (G-E) particularly outside the US.

It was US economic strength and domination that ensured that either Westinghouse or G-E would emerge as market leader. The US had the resources to develop nuclear power quickly; it had the huge companies to manufacture and sell the stations, and also to buy and run them; and it had the leverage to sell them internationally. From 1955, the US offered foreign aid for building reactors in 'friendly' nations – provided they bought American. Italy, France, West Germany and Japan did just that. The inducements came at the right moment, before most countries were committed to any particular system, and were a vital factor in ensuring that Britain was eventually left carrying the AGR alone.

The PWR entirely dominates the international market. It has been adopted by countries such as France for their own programmes. Initially much of the reactor was imported from the US, but today Framatome, which is 15% owned by Westinghouse, builds the reactor in France. So the large French programme is now based on Westinghouse's PWR, and is built by an associate of Westinghouse which pays licence fees to Westinghouse.

Why has nuclear power been taken up by the developed countries? There are two main reasons. In the US, the energy companies were strongly attracted to capital intensive stations with comparatively low running costs. This is because US government price controls fix a maximum rate of return on capital employed. So the more capital intensive the company is, the greater the profit it can make. Even though the economics of nuclear plant compared to conventional stations are highly questionable, by 1978 there were about 70 nuclear plants running in the US, about 90 more being built and around 50 on order. These figures would be far higher were it not for the success of anti-nuclear campaigners.

In countries like France and Germany, much of the appeal of nuclear power lay in winning a degree of independence from imported oil. That dependence was underlined during the oil crisis of 1973, and crash programmes were drawn up to accelerate the growth of nuclear generation. The combination of public protest, the soaring cost of nuclear power, the declining growth rate and falling demand for electricity has meant slowdowns and cutbacks in these plans. But substantial programmes are still under way, as is the move towards the fast breeder reactor, which is supposed to give greater independence from imported fuel.

Costly Growth

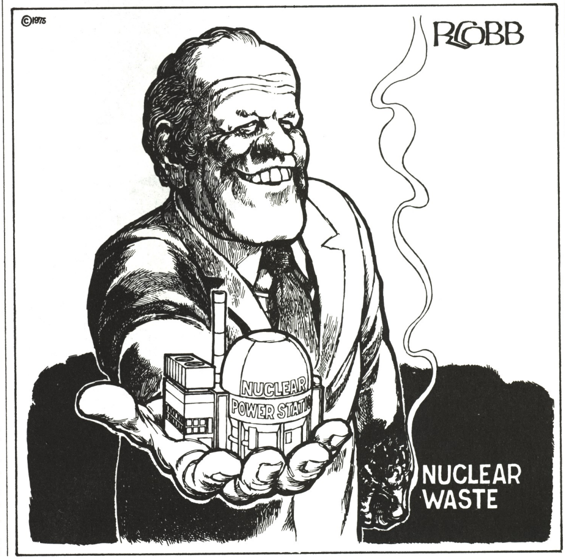
Over the past three decades, nuclear power has spread from being the exclusive province of the US and Britain to adoption right across the globe. Forty four countries now have firm, detailed nuclear energy programmes. By the end of June 1978, there were already 147 stations of 150MW or more operating in 16 different countries in the West. In addition there were some 16 stations of this size running in Eastern Europe.

Another 300 nuclear stations are planned or being built over the next 15 years. Although there is a good chance that many of these will never materialise, nevertheless at least a doubling of the world's nuclear power stock is expected. That in turn means a probable trebling of the power produced, given the growth in size of the stations.

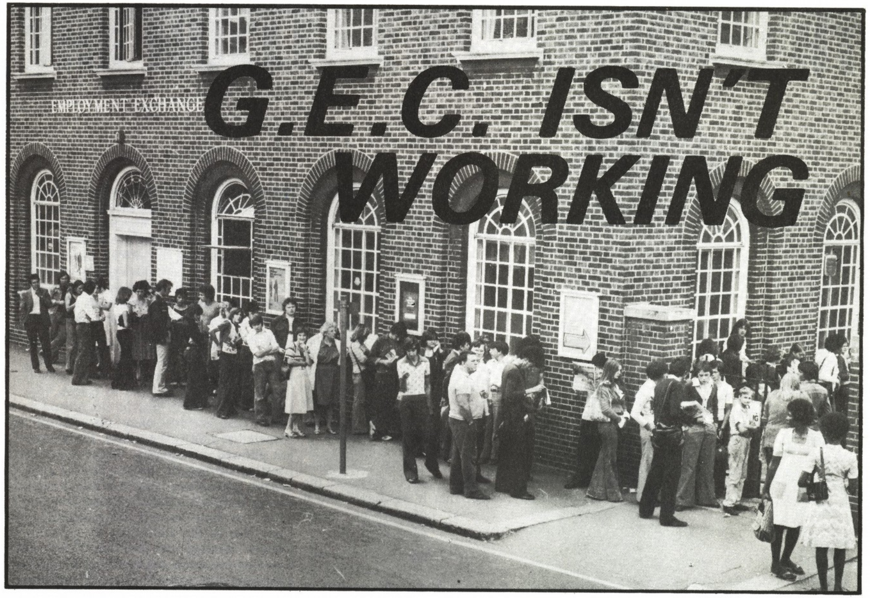
This growth will only be achieved at great cost. Even without the massive spending on research and development, the investment in mining, processing and reprocessing and waste disposal, we are still talking about spending at least $60billion.

The Third World

The spread of US technology into other developed countries has meant that indigenous industries have grown up that now compete with the Americans for orders. Each protects its own markets: the battle is for those markets without a nuclear industry of their own. That,



G.E.C. ISN'T WORKING



today, means principally the Third World.

With massive over-capacity in the world's nuclear plant industry, the battle for exports is intense. Companies scour the world for orders: South Africa, Iran, Philippines, Korea, Brazil and Romania are just some of the countries that have ordered stations over the past few years. The companies carry with them offers of special aid and finance – provided you buy from them.

For Third World countries without indigenous coal or oil, nuclear power offers several apparent advantages. Dependent on expensive oil imports, coal or nuclear energy are the only options. Coal needs investment in the supply infrastructure: ports, railways and so on. Hard hit by the increase in oil prices these countries are susceptible to the claims of the salesmen that nuclear power offers independence, and quick, cheap energy. Many are also convinced that nuclear capacity confers prestige and status.

But the decision to buy nuclear power has profound implications. The importing of a capital-intensive, technically sophisticated and highly unreliable technology has far reaching political, economic and social effects.

Faced with a growing mountain of debt, repayments and interest payments already take an ever-increasing proportion of the foreign exchange earnings of Third World countries. By 1974, the non-oil exporting Third World was already $125billion in debt, and 28 of them owed more than a third of their annual gross national product. 'Easy purchase' reactors, costing some $350million each, only serve to aggravate this position.

Dependence

The narrow range of suppliers of nuclear reactors, for there are still only half a dozen of the most industrialised countries with nuclear export capacity, makes a decision by any developing country a commitment to dependence on its supplier. Since India exploded a nuclear device in 1974, Canada has stopped delivery of spare parts for India's nuclear power plants, and the US temporarily cut off deliveries of enriched uranium for these plants. Instead of independence, going nuclear means greater dependence, technologically, financially and politically.

Nuclear power, besides being extremely expensive, has other drawbacks. It employs virtually no unskilled labour, while being a serious drain on scarce scientific and managerial personnel. Most serious, it is highly unreliable as a power source. In India, for example, with three nuclear power stations, power shortages are a major obstacle to development. One of the two stations at Tarapur is operational for less than 50% of the time, while both are operating at well below their design capacity. The third station at Rapp is running at a third of its capacity. Vital factories such as steel mills and fertiliser plants are badly affected by the electricity shortage. As the World Bank reported: 'The Indian Government has made a costly commitment to investment in nuclear energy for commercial purposes. But there is unrealistic allowance for the amount and reliability of supplies from these nuclear plants in view of experiences elsewhere in the world . . . For planning purposes, the present generation of nuclear power stations cannot be relied upon for sustained commercial operations at high load factors, as originally intended' (IBRD Report 1974).

Most serious of all, nuclear power threatens the process of industrial and agricultural development. It requires a concentrated, high energy industrial sector to service, the development of which centralises and unbalances development strategies. Politically, the scale and size of nuclear investment concentrates financial and decision-making powers in ever fewer hands, while the very danger that reactors pose serves to justify the existence of violent repressive forces to prop up the regime.

Big Business

The continued recession, and the growing debt problem, means that the market is limited. **Nevertheless, on a world scale it is still a multi-million dollar business. Eighty four nuclear plants were exported by Western suppliers between 1955 and 1977 – 52 of these after 1970. The pace slowed significantly in 1976 and 1977, but there were still orders for 14 stations in 1978, which represents some $5billion of business.**

Recently, despite increased financial support from the government, US manufacturers have been losing out on the export orders. Until 1974, the US won over three-quarters of nuclear plant exports. Since then it has secured less than half the orders in a smaller market. The orders have largely gone to West German or French manufacturers using US technology. However, the devaluation of the dollar in 1978, and the massive scale of the US companies who have been involved with over 200 reactors in all, will probably change the situation.

For Westinghouse, in particular, despite the current dearth of orders and the widespread anti-nuclear campaigns, the outlook is comparatively bright. They have a large backlog of orders and income from licensees round the world provides additional profits. There is, however, one market that the company would dearly like to break into, and that is Britain.

The only PWRs manufactured here at the moment are the small ones built by Rolls-Royce and Associates for nuclear submarines. Under license from Westinghouse, 13 have been built for the Royal Navy. GEC has also had close contact with Westinghouse, both through its advocacy of the PWR for Britain and through GEC Reactor Equipment Ltd, its nuclear reactor component manufacturing subsidiary. This has won contracts to supply equipment for Westinghouse reactors, particularly for the Ko-Ri power stations in Korea.

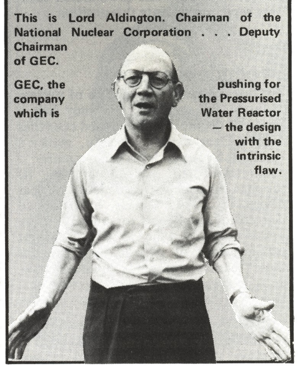
So Westinghouse already has a working relationship with these two important British companies. The question is whether the government's 'intent' to build a PWR will be turned into reality.

Rolls-Royce's recent proposal may prove a method of by-passing safety objections. It is novel in that it proposes small PWR stations of the order of 250MW – that is one-fifth the size of the giant twin reactor stations currently being built – which would be constructed on a barge in a waterside factory and then floated to the site. Factory construction allows far higher quality control, and the smaller size would allow proponents of the scheme to argue that it was safer. And it would have great potential in export markets.

Rolls-Royce, when pressed, admits that such a project would almost certainly be beyond its own resources. As recently as 1975 Rolls-Royce and GEC formed Ship Propulsion Ltd to design and manufacture marine propulsion plants and to tender for a PWR for a Canadian ice-breaker. GEC would be the obvious partner in the new project.

The real problem for the companies lies in persuading the British government to commit itself to the PWR reactor. The only way GEC can hope to expand significantly and competitively in the international market for PWRs and components without committing large amounts of capital is if a large part of the capital costs have already been paid. That will only happen when a PWR is ordered by the British government.

I SHOULD WORRY



This is Lord Aldington. Chairman of the National Nuclear Corporation . . . Deputy Chairman of GEC.

GEC, the company which is pushing for the Pressurised Water Reactor – the design with the intrinsic flaw.

Trojan Horse

The first reactor of a new design is treated as a one-off exercise. Extra money is allowed for original design work and setting up special tooling, testing equipment, and so on. It is, in effect, a capital contribution to the supplying company, but the state accepts the obligation to pay this as the alternative to ordering a larger number of reactors. Once that tooling has been set up, there is nothing to stop the company concerned from winning orders from overseas. Should it do so, there is no obligation to repay the original contribution.

That is why the companies are acting as the Trojan Horse for Westinghouse's entry into the British market. It is for this reason that they want to see the safety objectors defeated.

Safety is the Achilles hell of the PWR. The design is intrinsically flawed, because the moderator and coolant are one and the same. If the pressure vessel ruptures and the water runs out, the system is totally dependent on emergency systems operating despite the rupture. Failure could lead the core to overheat and melt through the vessel into the ground, giving off huge clouds of deadly radioactive dust. It is precisely such fears that have caused serious problems in obtaining licences for nuclear stations in the US. The comparatively open structure of the safety agencies in the US means that information is relatively available, unpalatable truths difficult to suppress. The agency in Britain, the Nuclear Installations Inspectorate, plays a far closer hand.

Safety objectors have less influence in the Third World. The big companies will build their markets in such countries without a qualm. But in Britain they need state help.

THE NUCLEAR ESTABLISHMENT

The British nuclear industry is dominated by a small group of powerful men, whose over-riding interest is the promotion of that industry. Whatever crucial decisions have to be taken, the same people are involved, and they all have a vested interest in the outcome. It is hard not to come to the conclusion that some form of nuclear 'cosa nostra' is at work.

At the very centre lies the Atomic Energy Authority (AEA). Its strength and influence rests on the fact that it is the only centre of expertise in the country, and is the sole advisor to the Government. "We take the Authority's word for it," said Tony Benn in 1967, "it is not necessary, right or proper, or possible for us to have within our Ministry a complete organisation for the duplication, review and evaluation of the advice given to me by the Authority."

So the AEA is in a rare position: its own power rests on the size and importance of the UK nuclear industry, yet it is the only advisor to the Minister responsible for determining the scope and development of that industry. It is the only training ground for industrial nuclear experts. This means that the Authority, for all practical purposes, is unassailable. It also means that most of the leading people in the industry have at one time or another worked for the Authority, and by and large reflect its aspirations. The extent to which former AEA staff dominate the industry can be seen in the Nuclear Power Corporation. At the time of its formation, the Deputy Chairman, the Managing Director, one of the Deputy Managing Directors and a Director with special responsibility were all ex-AEA men.

Similarly, the Central Electricity Generating Board (CEGB) demonstrates how important the role of the AEA is in helping the careers of the nuclear decision makers. The chairman of the CEGB from 1957 to 1962 was Christopher Hinton, who had previously been head of the AEA. One of the five full-time members of the present Board is J.A. Jukes, who was with the AEA from 1954 to 1964, while Alistair Frame, a part-time member from 1974 to 1978, spent four years as

Keystone

Atomic Energy Authority Propaganda material, designed to present Nuclear Energy as entirely harmless.

Director of Reactor Research at the Authority. D.R. Fair, a member of the CEGB until 1977, had been at the AEA in the years up to 1962. These are just some of the public figures: there is a hard core of managers and technicians within the CEGB who gained their pro-nuclear commitment during their years at the AEA.

The same applies to the Department of Energy and the Nuclear Installations Inspectorate (NII). Until recently, Sir Walter Marshall, ex-head of the AEA, was chief scientist at the Department of Energy, while the NII is almost entirely staffed by people from the AEA.

Monopoly

The AEA monopoly of research and development in nuclear weapons and nuclear energy dates from 1954 when the state corporation was set up by special charter. It operates in a climate of strict secrecy with most of its employees subject to the Official Secrets Act. Employees working on its various projects are subjected to strict security vetting and are bound not to make any unauthorised disclosure of information which has been acquired while working for the AEA. Even Parliament is denied information on aspects of its civilian work, for example the Fast Breeder Reactor project, and no Parliamentary discussion is allowed on the arrangements for moving plutonium around the country.

The AEA has its own private armed police force, currently 400 strong. This force is answerable not to the Home Office, but to the AEA. It has the power of armed pursuit, the right to enter any premises at will, and the power to arrest on suspicion.

The AEA is a large state organisation, with a turnover of well over £100million a year, and over 1,300 employees. In the years since its formation it has received £4billion of public money, at today's prices, but this vast expenditure has rarely, if ever, been challenged.

It has played a central role in the history of the UK nuclear industry, in particular exerting heavy pressure on the CEGB and the government to accept the AGR programme. It was felt at the time by many within the Authority that a decision to use imported technology for the second nuclear programme would deal a body blow to the AEA's power and prestige. More recently, as the extent of the problems over the choice of the AGR has become clear, the AEA has had to be more circumspect. In the recent evaluation of the Steam Generating Heavy Water Reactor (SGHWR) against the Light Water Reactor (LWR), the AEA stayed on the fence, not supporting either side.

The private companies are also tied into the AEA, not only by commercial interests, but also by a chain of interlocking directorships. The National Nuclear Corporation (NNC), now the sole design and construction company for nuclear stations shows the links.

GEC has two directors on the board of the NNC one of whom is Sir Richard Royle Powell. Sir Richard is also a director of Whessoe Ltd. The chairman of Whessoe is Lord Errol of Hale, who was Parliamentary Secretary at the Ministry of Supply from April 1955 to November 1956, and Minister of Power from 1963 to 1964. It was Whessoe Ltd who obtained the contract for the reactor vessel on Dungeness B.

Keen Interest

The Deputy Chairman of the NNC is Lord McFadzean, who has always taken a keen interest in the nuclear industry. Between 1964 and 1966 he was involved with the British Nuclear Forum, a trade association formed to promote the nuclear industry. Among his many directorships Lord McFadzean is Honorary President of British Insulated Callenders Cables Ltd (BICC). He was the Managing Director of BICC from 1954 to 1961 and its Chairman from 1954 to 1973. One of BICC's subsidiaries is Balfour Beatty, which obtained the contract for the civil works on the Dungeness B nuclear power plant.

The development of the nuclear energy industry in this country owes everything to these men, and reflects little more than their own self interest and narrow vision. Nuclear energy development has never been the subject of political debate, rather it has been promoted and approved by the small group of men who make up the nuclear establishment. In no other area are such fundamental decisions immune from some degree of public scrutiny, and as long as those responsible remain unaccountable, the disaster will continue.

The AEA people:
Chairman Sir John Hill, also BNFL & Radiochemical Centre Ltd
Dep. Chman. Dr W. Marshall
Full Time Member A.M. Allen
Part Time Members:
C. Allday: Ex ICI
Sir Brian Flowers
Dr N. Franklin: NNC, NPC
Lord Kearton: Hill Samuel; BNOC; Electricity Supply Council
F.E. Bonner: Dep.Chmn.CEGB
B.G. Tucker: Dep.Sec. Dept of Energy
W.B.S. Walker: Peat, Marwick, Mitchell & Co
Sir L. Williams: Civil Service Appeal Board; Civil Service National Whitley Council (Staff Side) etc.

The AEA has 13 research and experimental reactors located at four establishments: three at Harwell, the largest establishment, eight at Winfrith, one at Windscale and the Prototype fast reactor at Dounreay. It is the latter that receives the greater part of the AEA's attention nowadays: in 1976/7 fast reactor research and development accounted for a larger part of the AEA's expenditure than any other single item.

The authority employed the following staff at 31.3.1977:

Qualified scientists & engineers		2,598
of whom –		
gas-cooled reactors	110	
fast reactors	675	
water moderated reactors	160	
nuclear safety & environment	385	
fuel processing etc	450	
nuclear R&D, and services on repayment	290	
non-nuclear research	310	
Other non-industrial staff		6,149
Industrial Staff		4,535
Total		13,282

THE PRICE WE PAY

'A New Renaissance might well be within sight, and the leisure hours which nuclear energy could bring to the great mass of the people may well lead to a Twentieth Century equivalent of the Golden Age of Elizabeth I' (*Atomic Power,* 1955).

A whole generation has been brought up with the promise that nuclear power would bring inexhaustible and above all cheap energy to all. Atomic energy would transform our lives, save the Third World from hunger, make electricity as cheap and available as water – nuclear power was billed as 'the most promising of all the discoveries made by man' (Lord Eccles).

At every point when decisions were made to continue or expand the nuclear programme, the promise of cheap electricity was the major inducement and justification. Every time, that promise was proved false by events.

The course of Britain's nuclear development was largely set by the decisions taken in the years 1955 to 1957, when the first nuclear programme was chosen, based on the gas-cooled (Magnox) reactor.

'The increased programme of 1957 was in part a panic reaction to the Suez crisis (which threatened oil supplies), but it would not have occurred without a grotesque overestimate of the technical and economic significance of the Calder Hall plant. Most advocates of the 1957 programme appeared to believe in Hinton's forecast that power from Magnox plants to be completed in 1962-63 would be cheaper than power from new coal fired stations.' (Burn p.12)

Soaring Costs

By 1958, that forecast was recognised by everyone, including Sir Christopher Hinton of the Atomic Energy Authority, as unfounded. The programme was deferred for a year in autumn 1957 to help reduce inflation, and the early Magnox stations took longer and cost more to build than was forecast. By 1960 the Central Electricity Generating Board (CEGB) was pressing for further curtailment of the programme. By 1962, when electricity finally came from the first Magnox Plant, it cost 80% more than the 1957 estimate.

The cost was to rise further. Within ten years all the Magnox stations had to be derated – put onto lower power – because of unexpected levels of corrosion. Even so the CEGB now states that they are cheaper than the alternatives. A simple accounting device hides the truth. 'The capital charges for the Magnox stations were adjusted so that the generating costs derived from them reflect the effects of derating – ie a proportion of the capital charges have been written off.' (Sweet) The CEGB admitted this in evidence to the Select Committee in 1972-3 (p97), but now publicly denies it.

In 1965, Fred Lee, Minister of Power, made his famous announcement that 'We have made the greatest breakthrough . . . We have hit the jackpot this time!' It was the most outrageous of many extravagant claims made by politicians and industry spokesmen alike for what was to turn out to be the biggest fiasco of all, the AGR programme. The CEGB had produced figures claiming that electricity from the first AGR would be 0.01p per unit cheaper than could be achieved using an American reactor design. But the only breakthrough that Dungeness B represents is the scale of its disaster.

Fred Lee's optimism was reflected in the important White Paper of 1967 on fuel policy. It proposed fundamental changes in the pattern of energy demand and supply in the coming years. Central to the argument was the government's view that the AGR programme would break through the floor prices of electricity generated by the most efficient of the fossil fuel stations. The first Magnox station (Berkeley) had a stated generating cost of 1.27p per unit. The Dungeness B AGR, then scheduled for commissioning eight years later, was expected to achieve a cost as low as 0.22p per unit. Once again, decisions were taken that would cost millions of pounds on the basis of highly dubious claims about future costs.

Cover Up

The AGR programme is the worst example of the failure to predict costs with any degree of accuracy. Its true cost to date has never been published. Originally, the four AGRs being built for the CEGB were

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Popperfoto

Fred Lee – Minister of Power 1965 . . .
His 'jackpot' was only for the companies.

to cost a total of £418million. By October 1975, ten years after the original order, by which time the programme should have been completed, the cost was estimated at £880million. In June 1977, Benn told Parliament that the estimated cost of these four reactors, plus Hunterston B, built for the Scottish Board, would be £1,150million. Six months later the price of the Heysham reactor alone was given as 'altogether £360million' in connection with an EEC loan of £52.3million to complete it. **In official figures the total programme must now be running at around £1,300million. That is an approximate 350% increase over the original estimates.**

But the official figures are just the small beginnings. Independent analysts agree that the true capital cost of the AGR programme, including interest but excluding research and development, will be well over £3billion – a 600% increase. Colin Sweet, in evidence to the Windscale enquiry, estimated the cost at £3.5billion (table 1). Professor David Henderson of University College London puts the cumulative cost to March 1978 alone at £3.7billion. And the figures come just as large from the other side of the nuclear lobby fence. Translating Duncan Burn's 1975 prices gives a figure of over £3billion capital cost and over £5½billion in all (table 2).

Despite these astonishing escalations in cost, the programme remains uncompleted. The first, Dungeness B, is still not working – begun in 1965 its completion date has been pushed back further and further. It now stands at 1981. The completion dates on Hartlepool and Heysham, begun in 1968 and 1970, have also been put back to 1981. The AGRs are cumulatively 15 to 20 years behind schedule. The price of their fuel has risen eightfold at least since they were ordered. There have already been failures at the two plants that are working, and one is out of operation for repairs for at least a year. Continually rising cost estimates, extended completion dates, operating failures . . . Will Dungeness B ever work? Where will it all end?

This pattern has been repeated throughout the history of the nuclear programme. Estimates of cost have been wildly below the eventual reality, and the lure of cheap electricity remains a promise for the future. The evidence of the past gives no confidence to the claims and promises of the present.

Wild Claims

The CEGB claims that nuclear power is now cheaper than that from fossil fuels – and of course its figures are bandied about by all those with a nuclear axe to grind.

'The economic advantage to be derived from installing nuclear power is now well established. British nuclear stations have in recent years shown a consistent advantage over fossil-fired stations . . . The Central Electricity Generating Board recently estimated that each of their AGR stations will reduce the overall cost of electricity by £1.5m per week.' (UK Atomic Energy Authority Report and Accounts 1977/78)

Increases have occurred in the costs of reprocessing nuclear fuel, but there remains a wide unit cost advantage for nuclear power stations relative to conventional plant.' (CEGB Report and Accounts 1977/78)

The CEGB currently claims that nuclear power based on historic costs is now some 35% cheaper than coal, and 50% cheaper than oil. It stresses that each of the AGRs currently being built will, when functioning, save £90m from the annual fuel bill.

On what are these grandiose statements founded? Not on facts that the CEGB is willing to expose to public examination. **It is impossible to find out the real total economic costs of generating electricity by different systems: none of the published figures are total costs, and to confuse matters further, the figures that are released do not correspond with each other.**

Why is it impossible to get an official figure for the AGR programme, when it is our money that is being spent to build them? Because the figures would embarass and confound the policy makers? How is it possible that over £3billion has been spent on a series of stations that do not work, that nobody in the rest of the world is prepared to have anything to do with, and no questions are being asked – or answered?

Capital Costs

The nuclear establishment evidently has a great deal to hide and the CEGB, which supplies electricity to England and Wales, is a crucial part of that establishment because it actually operates the nuclear plants. The CEGB has been fully committed to nuclear energy from the start, and has consistently encouraged its growth and continuation. It is the CEGB that bought eight of the nine Magnox stations and four of the five AGRs. Information on their operating costs can only come from the CEGB or the operator of the two other stations, the Scottish Board. It is this information

Table 1

Capital costs of the AGR programme

	Construction £m	*Interest during construction £m*	*Initial inventory plus interest for 3 years £m*	*R & d charge*	*Total cost of reactor £m*
Dungeness B	320	224	132	n.a.	584
Hartlepool	250	137.5	132	n.a.	427.5
Heysham	270	135	132	n.a.	445
Hinklet B	147	63.5	132	n.a.	252.5
Hunterston B	163	72	132		275
Total cost of programme	1,150	634	662	n.a.	2,446
Total cost of 1980	2,446 + R & D				
plus interest of capital over 20 years	971.25				
Total cost	3,417 + R & D				

This table is based on the evidence given at the Windscale Inquiry. C. Sweet, Supplementary Proof of Evidence. Day 71.

Table 2: Total Cost of AGR programme (£m, 1975 prices)

Construction cost including IDC	**2100**
Initial fuel cost	**200**
R and D – AEA	**400**
– CEGB	**100**
Cost of electricity from alternative sources	**1000**
TOTAL	**3800**

Burn, p.141

that, in 1978, is used to justify spending many more millions on two further AGRs.

Revealing unpalatable nuclear power costs would undermine the whole nuclear establishment. It would raise the question as to how hundreds of millions of pounds could be wasted by a public utility in this way, why so much money and effort had been misdirected when the economy as a whole was so critically short of resources. Not surprisingly, from the 1965 'jackpot' fiasco onwards, CEGB figures have been inadequate and inconsistent.

Capital costs are crucial to the pricing of nuclear power. The initial costs of nuclear stations are much greater than for conventional plants, while fuel costs are held to be much lower. Anything that reduces the impact of capital costs in calculating generating costs swings the balance heavily in favour of nuclear power. The methods used by the CEGB to measure the capital costs of different types of power station are bound to slant the figures in favour of nuclear stations.

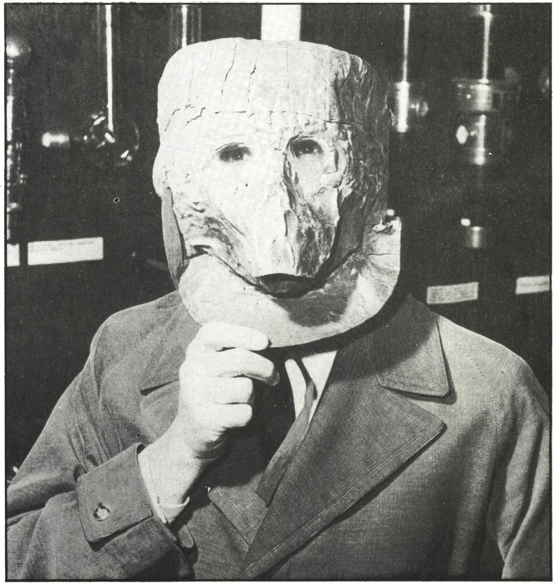
The figures that are proclaimed by the electricity supply industry give the impression that nuclear generated electricity costs 0.76p per unit as against 1.23p per unit for that from its nearest competitor, coal. That is over one third cheaper! Then you read the print more closely. This is for power from the Magnox plants, on which most of the capital spending occurred more than ten years ago.

Claimed Generating Costs, 1977-78

Coal	**1.23p per unit**
Oil	**1.42p per unit**
Nuclear	**0.76p per unit**

In the meantime, much has changed. For a start there has been massive inflation. The US Atomic Energy Commission reported in 1974 that the capital costs of nuclear power had risen 500% in the previous five years. In Britain, prices have risen considerably since then: £100 of capital from 1967 is worth £250 now.

A realistic costing of power produced by such old plants has to take account of inflation. It is not enough to share out the original costs of the station – the cost of replacing worn out plant and machinery at today's prices has to be considered too.



Popperfoto

Cheap at the price – 1919 Radiation Shield.

The CEGB recognises the importance of accounting for inflation in its own accounts: it included a supplement of 40% on its depreciation allowance in 1977-78 to allow for inflation. But in proclaiming the cheapness of electricity from the Magnox stations, the CEGB makes no allowance for inflation . . . its published comparisons are based on historic, or original, capital costs. But it does use today's prices for the fuel costs. This means that the capital costs on all stations are underestimated, but because these are such a crucial part of nuclear costs, comparisons are automatically distorted in favour of the Magnox plants.

Interest Costs

It's made worse by the CEGB's accounting policies which minimise the capital cost in the first place. The Magnox stations took from six to ten years to build. During that time interest had to be paid on the capital costs, before any revenue was earned, amounting to many millions of pounds. This money is itself a capital cost – it is part of the cost of building the station. It ought to be treated as such and shared out, together with the interest due on it, over the life of the plant. The CEGB does not include interest during construction as a capital cost.

Again, the research and development costs of the nuclear reactors are enormous. In the early years they will be as large as the construction costs. For the years 1962 to 1973, nuclear research costs have been put at £813million (Surrey and Walker, Energy Policy June 1975). A figure for earlier years is not available, as civilian reactor costs cannot be separated from military expenditure.

The research costs of the nuclear reactor programme were accepted in 1967, when the CEGB agreed to pay a royalty to the Atomic Energy Authority fixed at 0.014 old pence per unit. It was understood that this was less than the actual cost of the research, the true cost of which was treated as confidential. The rest of the costs were written off as being a 'benefit to the nation'. How much was written off? The National Coal Board suggested at the time that the real cost lay between 0.03 and 0.05 old pence per unit, or two to three times the proposed royalty.

Today this royalty is not included in the CEGB accounts. Nor is the cost of the original research and development included in the calculation of nuclear generating costs.

Closure Costs

Then there are the decommissioning costs. As the American energy companies are now finding out, the costs of closing a nuclear station, and trying to ensure its safety once closed, can be as much as the cost of building them. The anticipated closure costs are just as much a capital cost as the construction costs, and should also be shared over the useful life of the plant. The CEGB has put aside a mere £20million in its provisions for nuclear plant closure so far – a totally inadequate figure.

All these factors: ignoring inflation; not capitalising interest during construction; leaving out research and development costs; and only allowing inadequate decommissioning costs; weigh heavily in favour of the Magnox stations as they were built in the relatively distant past. Small wonder that the CEGB can claim such extravagantly low generation costs for them. They give a total cost of 0.76p per unit in 1977-78. Yet, according to their Statistical Yearbook for that year, running costs alone amounted to 0.64p per unit – and that included some AGR power, which has, according to the CEGB, lower generation costs. That gives a capital cost of around 0.12p, or less than 16%. This can be compared to the traditional nuclear cost syndrome of 70% capital cost and 30% fuel cost. It can also be compared with recent estimates by the CEGB for AGR generation costs, which show a 35%/65% split.

Reticence

The very reasons that allow the Magnox costs to be accounted so attractively also explain the Board's reticence about revealing estimated AGR generating costs. In their case, sufficient time has not yet elapsed as to allow inflation to take its toll of the tremendous capital overspending. The even more extended construction times and higher interest rates have meant that interest during construction is that much larger and more difficult to hide. Of the total expenditure on the AGR programme up to 1975-76 of some £1,100million (in prices at time of payment), no less than £375million was interest during construction – 34%.

With all the mistakes involved in the AGR programme, the redesigns, modifications and reconstructions and so on, the burden of research and development has been especially heavy. The total research and development costs for the AGR programme have been estimated as £500million, of which £400million was spent by the AEA and £100million by the CEGB. (Burn)

Double The Price

Full and proper accounting would no doubt produce horrendous costs for the electricity produced by the AGRs. We can only guess at them and say clearly that, for all the reasons outlined above, they are far higher than the CEGB will admit. Industry figures leaked to the ***Electrical Review*** **(3.2.78) give a total generating cost in January 1977 prices of 1.48p-1.67p per unit. This is over twice what the CEGB claimed in evidence to the Windscale enquiry. It is also much more than the proven cost of generation from coal.**

There are several reasons for the cover-up. There is reluctance, understandably enough, to admit the true extent of the costs. This reflects both the outcry that would result, and the determination of the CEGB's long-standing commitment to nuclear power. That commitment is founded partly in the sheer power that spending vast amounts of capital confers upon the Board. It is buttressed by the hard core of executives in the CEGB whose careers started within the AEA and have been built on the nuclear programme. It is also based on the continual search to find a viable alternative to coal as the fuel for base load electricity generation.

The Department of Energy has produced its own comparisons of nuclear energy costs compared with that from coal. 'A nuclear station, and particularly one with a Pressurized Water Reactor, is shown to have an overall cost advantage, unless it is assumed that a successful investment programme has enabled the coal industry to keep costs down to very near their present level.' (*Nuclear Engineering International* April 1978)

This is only achieved by making many dubious assumptions. One is that the nuclear plant is the fourth of a type – as the AGR experience has shown, the possibility of ever reaching that stage is extremely remote. The contingency for escalation in construction costs is just 17½%, far less than the reality experienced with the AGRs. Interest charges during construction are also omitted – they accounted for about one-third of the true capital costs of the AGR. And the total of research, launching and decommissioning costs is put at only 5% of construction costs.

Despite these many shortcomings, the Department's assessment can be seen to reveal that nuclear power depends on rising coal prices for its viability. And if scarce public capital resources are pumped into nuclear power rather than coal, then, as the assessment shows, the investment will be self justifying. Coal prices will rise further. But it is the spectre of the miners throttling the power stations' fuel supply that provides reason for the CEGB's commitment to nuclear power; whatever its true economics.

Miners

The CEGB buys 65% of the National Coal Board's (NCB) output. By the same token, coal provided, in 1977-78, 70% of the CEGB's fuel. The CEGB can thus influence coal prices, as well as being vulnerable to price increases. In the 1977-78 Annual Report, for instance, the CEGB states that 'because the other markets for coal are still depressed . . . the Board has undertaken to accept a record 72million tonnes of NCB coal in 1978-79. This is over 3.5million tonnes more than the amount taken in 1977-78. The Board gave this undertaking even though the power stations were holding record stocks of coal at the end of March 1978. The main condition attaching to the undertaking is that the price of NCB coal to the CEGB should not be increased during 1978-79. In this way the CEGB will be helping the NCB to reap the benefits of its pit-based productivity scheme.

The CEGB buys enough coal to force the

NCB to keep the price down for a year – which in turn means the NCB will have to try to keep the miners' wage bill down. The target will be to offset any wage rise won against higher productivity, using the productivity deal forced through in 1977, regardless of the cost in terms of lives or jobs. For the CEGB, a larger base of nuclear power stations, producing power at what is claimed to be far lower cost than coal, will greatly strengthen their hand in demanding the price of coal be held down. Whatever the economics of nuclear power, that could limit the cost of their fuel as a whole if it can be used as a bargaining counter to threaten the militancy of the miners.

Who Pays?

As always, it is we who pay for the disastrous decisions made in our name, but beyond our supervision or control. Enormous sums of money, greater by far than the amounts spent on the much publicised Concorde or British Leyland, have been spent. Vast amounts have been misused and squandered in the attempt to keep afloat a private nuclear industry that would one day be able to cash in on a highly profitable market. Companies have kept their nuclear interests alive on cost-plus government contracts, while they jockey for position and the weakest are driven to the wall. The electricity suppliers in their monopoly position just pass costs straight on to the consumer, who has no choice but to pay up.

As taxpayers, we pay for almost all the research and development costs of nuclear reactors. The Atomic Energy Authority is paid each year by direct Parliamentary grant – an almost automatic process. In 1977/78, this amounted to £101.5million. Since its formation, the AEA has had over £1,300million of taxpayers' money – in today's prices nearly £4billion.

As electricity consumers, we have no choice but to pay the sole supplier. Building uneconomic stations means higher electricity bills. The CEGB's under-accounting of the price of nuclear generated electricity has its other side: the price of fossil fuelled electricity is pushed up faster. Before the AGRs had produced any electricity, the cost of building them was helping to inflate electricity prices. Since 1970, while workers were being told that wage control was vital because wage increases caused inflation, the AGR programme increased the CEGB's costs significantly. The result was an increase of 277% since 1970 – the year that Dungeness B was supposed to be finished. Since 1975, when the whole AGR programme was to be completed, the cost of electricity has risen by 135%.

The losses on the Hunterston B reactor in Scotland, which will be out of service for at least a year, could lead to direct increases in the electricity tariff in Scotland. The loss to the Generating Board of one year's revenue would be £40m, and to this must be added the cost of maintenance, repairs and staffing for one reactor.

Electricity prices matter. Each winter tens of thousands of old people have to choose between food and heating – and each winter thousands of them die of hypothermia, cold. Each year thousands of families are condemned to the dark and cold, as their electricity is cut off when they can't pay their bills. Electricity is not just another commodity, to be bought or not at will – it is a social necessity. And the generating boards, as sole suppliers, have a social responsibility to ensure that it is supplied as cheaply as possible. The disaster that the AGR programme represents, and the refusal by the CEGB to give the information necessary to ensure that the disaster is never repeated, are a failure to live up to that responsibility.

THE JOB DECEPTION

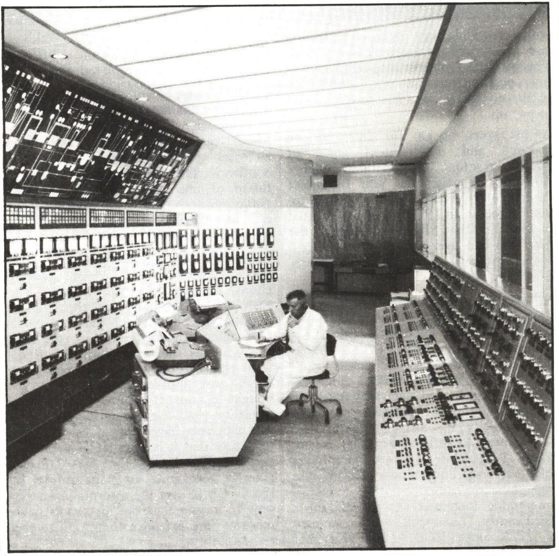
Those in favour of the expansion of nuclear power often argue for it on the grounds that it creates jobs. At a time when over 1½ million people are out of work such arguments are attractive. But they are untrue.

The total number of jobs in the electricity supply industry fell from 221,000 in 1968 to 160,000 in 1978, a loss of over 27%. Over the same period the amount of electricity sold increased by over 30%. The nuclear-generated part of this also increased. Between 1967 and 1976 the number of people employed in nuclear power stations did go up by 23% from 2,980 to 3,660. Generating capacity in the same period increased by 41% however.

While more electricity was being supplied by nuclear energy, smaller power stations were closed and jobs were shed. The programme of closures has been accelerated by the recent decline in demand for electricity, and has caused the loss of thousands of jobs (4000 in the six months to March 1977 alone).

The shift from coal and oil to nuclear power threatens more jobs than those in the electricity supply industry itself. As we point out elsewhere in this report, the CEGB purchases enough coal from the National Coal Board to be able to exert considerable pressure on its price. This pressure is causing further rationalisation and productivity increases in the coal mines, leading to further manning reductions and decreased safety. The supporters of nuclear development also never discuss the inevitable logic of the effect large-scale nuclear-energy derived electricity would have on coal miners' employment in the long term.

Control room of the Windscale reprocessing plant.



UKAEA

It is also argued that the development of nuclear energy facilities can produce a beneficial increase in employment at the local level. Because of the safety hazards nuclear plants are located away from urban centres, in areas where there is usually a high level of unemployment, and any increase in jobs is welcomed. But again evidence suggests that the benefits are overstated.

In 1976 a report was produced by the local County Planning Officer assessing the effects on local employment of building a power station in Gwynedd in Wales (The Impact of a Power Station on Gwynedd, 1976). The report pointed out that while the Magnox station at Wylfa was being built, even though 2,600 people were employed on its construction, the total local effect was a reduction in unemployment of just 282. After the plant was completed, unemployment in Anglesey was higher than it had ever been. Thus it is clearly demonstrable that local employment receives little or no long term benefit from nuclear reactor construction. The majority of permanent staff in fact are specialists brought in from outside.

At the inquiry into the Windscale development BNFL suggested that it would create 1,400 extra jobs. The local authority however estimated that about 700 jobs would be generated, and these over a ten year period.

All new technologies tend to displace jobs. But in the electricity supply industry the arguments in favour of nuclear development always founder on the fact that no equivalent research has been done on alternatives. It was argued at the Windscale inquiry that calculations carried out in the US suggested that the development of solar power, for instance, could create two and a half times as many jobs as the nuclear programme.

It has so far been ignored that other forms of electricity supply and energy conservation technology could create more jobs. For example, the nuclear programme has effectively monopolised massive resources which could have been used to develop safer, more efficient coal utilisation. With the present structure of the industry, however, the vested interests that control it will ensure that those alternatives are never explored.

THE FUEL CYCLE

Alongside the UK nuclear programme, almost unnoticed, a servicing industry has grown up which is now preparing for a major expansion. Desperate for a foothold in what it considers to be a growth industry, the UK nuclear fuel industry is seeking major contracts to supply and treat fuel for foreign atomic programmes.

British Nuclear Fuels Limited (BNFL), a wholly owned subsidiary of the Atomic Energy Authority (AEA), is turning processes which were developed for the nuclear weapons programme into quasi-commercial operations. The restrictions on public scrutiny that accompanied the military build up remain. Large sums are being spent on major development programmes, with almost no public accountability.

BNFL was set up in 1971. It is a wholly owned subsidiary of the AEA, and its executives are all members of the AEA. According to its Annual Report, BNFL is responsible for procuring uranium, making it into fuel for reactors, and disposing of spent fuel. In addition to this, 'the company seeks business overseas in order to achieve a greater measure of growth than that offered by the UK market alone'.

In 1978, BNFL had a turnover of £161.6million, and employed over 12,000 people — nearly two thirds of them industrial workers. This year it will implement decisions that will make Britain's nuclear future even more certain. Ironically, as each year passes, more and more of BNFL's work involves mopping up the effects of past decisions; e.g. disposing of 20,000 tonnes of depleted uranium accumulated from the weapons programme of the 1960s.

BNFL operates in four main areas: fuel conversion and enrichment; waste management and disposal; fuel reprocessing; and the manufacture of by-products of nuclear technology.

The 'waste' from nuclear reactors is misnamed. Since 1947 waste or irradiated fuel from reactors has provided plutonium for nuclear weapons. It also contains uranium which can, with considerable care and cost, be recovered. For example, a tonne of irradiated Magnox fuel contains 998 kilos of unconverted uranium and 800 grammes of plutonium. So the burnt fuel from reactors is not simply discarded, it is saved, processed and reused. Yet it is so hazardous that the entire process must be carried out by remote control using devices that are unlikely to need repair or maintenance.

Mutated frogs found near Nuclear Research site.

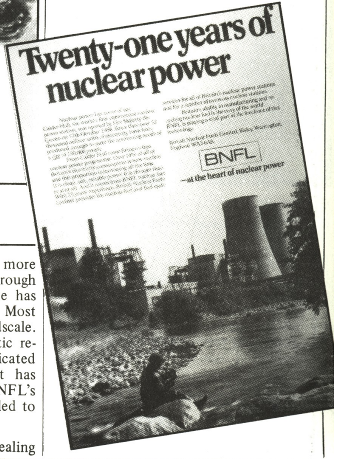
Popperfoto

As reactor technology has become more sophisticated, from Magnox, through AGRs to Fast Breeders, this waste has become more and more hazardous. Most of the reprocessing is done at Windscale. The increasing demand for domestic reprocessing, and the ever more sophisticated technology required to handle it has necessitated expansion. It was BNFL's request to build a new plant that led to the Windscale Enquiry.

Ironically, the enquiry was not dealing with anything new. In its reprocessing history the Windscale plant had already handled some 19,000 tonnes of spent nuclear fuel. Just what purpose the enquiry did serve is even less clear considering the massive refurbishing contracts being carried out on the old Windscale reprocessing plant by Taylor Woodrow. Costing a little under £400m it will involve the rebuilding of both the 'front' and 'back end' of the plant. No enquiry was required for this expenditure. The new chemical plant will cost an estimated £600m.

Japanese Prize?

Although details are not readily available, BNFL has been reprocessing spent fuels for other nations for some years, notably Italy. But it was the £900million contract to reprocess and transport Japanese reactor waste that aroused public concern. BNFL had bid for the contract long before formal permission to build the new Windscale plant had been given. It is not hard to see that the existence of this apparently lucrative prize played an important part in the outcome of the enquiry.


Twenty-one years of nuclear power
BNFL
—at the heart of nuclear power

BNFL Establishments

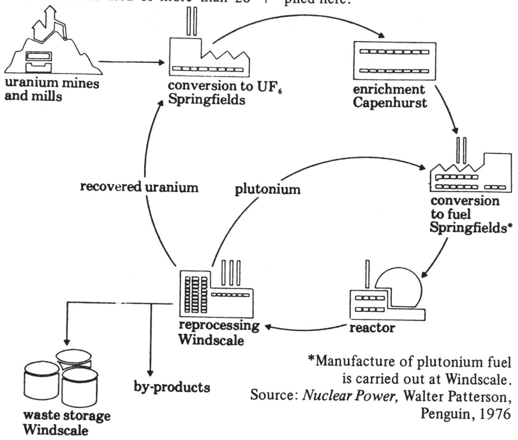
Springfields
Two crucial operations are carried out here. The base material for reactor fuel manufacture – uranium hexafluoride – is manufactured. After being enriched elsewhere, it is returned to Springfields, where it is made up into metal encased rods.

Capenhurst
Here BNFL receives the uranium hexafluoride (a viciously corrosive gas), and enriches it. That means that it concentrates the radioactive isotopes of uranium, so that it can be used as fuel for the AGRs and other thermal reactors. Traditionally, this has involved a lengthy and expensive process of diffusion, but for some years now BNFL has been involved with Dutch and German partners in developing a new technique. This new technique, which involves a chain of centrifuges, has been declared a complete success, and BNFL is plunging ahead to turn the pilot plant into a full scale operation.

The 'filtering plant' at Capenhurst that produces the bulk of Britain's nuclear fuel covers an area of more than 20 acres, with a production line almost a mile long.

Windscale
After being burnt in the reactors, the remains of the fuel are returned to the reprocessing plant at Windscale. This reprocessing plant must rank as the world's most 'continuous process industry'. It cannot be stopped or run down without great risk, which places severe restrictions on the 4,500 people who work there. Used nuclear fuel contains both valuable material and uniquely hazardous waste. At Windscale, the re-usable uranium, the plutonium, and the radioactive wastes are separated. Before reprocessing, the fuel and its metal cladding are held in a complex of huge cooling ponds. Smooth and reliable operation is essential. Recent bottlenecks have developed in the Magnox fuel reprocessing plant built in 1974, and a huge new plant is being built to alleviate this.

Windscale has also become the major storage facility for the radioactive products left after the extraction of uranium and plutonium. The bulk of the UK plutonium store is also stockpiled here.



*Manufacture of plutonium fuel is carried out at Windscale.
Source: *Nuclear Power,* Walter Patterson, Penguin, 1976

The secondary products from irradiated fuels, those left after the uranium is extracted, cause the most serious problems. Plutonium is the most well known. Originally reactors were run with the sole purpose of manufacturing this element for weapons production. Windscale has in fact separated as much as 10 tonnes of the stuff. Two and a half tonnes have gone into weapons, the rest remains in high security store at Windscale. **Even so, no less than 16 kilograms of plutonium was officially 'unaccounted for', from Windscale in the one year 1976/7.**

Plutonium is the most fissile of all the by-products of nuclear reaction. It remains a hazardous substance for thousands of years, and is therefore extremely difficult and costly to store. **The existence of this plutonium has quickly become the justification for the next generation of nuclear reactors – the fast breeders (FBRs). These run on a mixture of uranium and plutonium and can (in theory at least) be operated to either breed plutonium or incinerate it.**

The Bomb

But it is the capability of plutonium for weapons use that has caused the biggest reservations over reprocessing. President Carter has objected to the spread of commercial reprocessing as a major plank in his non-proliferation policy.

A similar fear seems to have been in the mind of the Windscale objectors when they pointed out that the increased production of plutonium would increase its availability. In these circumstances the possibility of its falling into 'terrorist' hands would increase, with the resulting erosion of civil liberties.

The latest Anglo-American idea for safeguarding plutonium against illegal diversion, is to put even more deadly ingredients into the reactor, so that anyone interfering with the fuel would receive a dose of radiation deadly enough to kill almost at once (*F.T.* 7.3.78).

No less of a problem are the other fissile by-products of nuclear reactors. These together with the liquids and gases used in reprocessing the irradiated fuel, have to be disposed of safely.

According to the AEA, 'low activity

WHAT A WASTE

The two faces of atomic waste: a handful of vitrified radioactive waste and below the disastrous Dungeness B power station. Both as yet unsolved problems for the nuclear establishment. How to store the waste that remains lethal forever. How to get the £600 million station to produce electricity.

UKAEA

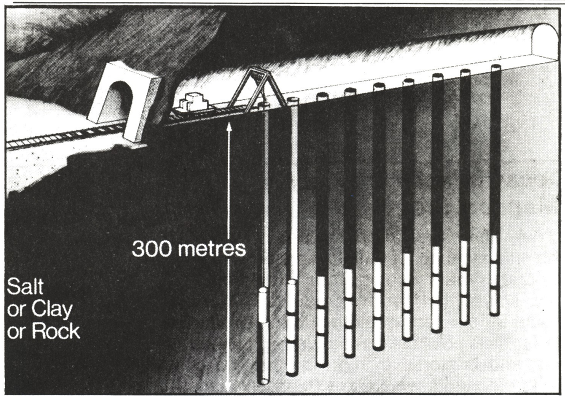
wastes are disposed of permanently and safely under a strict authorising procedure'. This means that radioactive gases are dissipated in the air, liquids in the sea, and other materials buried in the ground. Since 1967, over 46,000 tonnes of radioactive waste have been deposited in the sea by eight European countries.

The rest are held in licensed stores to cool while further treatment and disposal processes are being developed. Huge silos filled with water hold fuel cladding, while other irradiated substances are dissolved in acids. This in turn is reduced to a highly concentrated liquid which can be held for a limited period in high integrity stainless steel tanks. In the long term, the lethal heritage still presents an insoluble problem. The nuclear establishment speaks confidently about 'vitrification' – turning the waste into glass blocks, and storing it deep underground. But that is not the end of the problem for the authorities. As Lord Hill said: 'Unfortunately public misunderstanding of the position has in some places led to demonstrations to prevent investigations and studies of proposed disposal sites from taking place.'

False Profits

BNFL says in its annual accounts that it makes a profit, but only the most narrow of accounting perspectives could justify the £24.2million surplus that BNFL claims it made in 1977/78. BNFL's operations continue to benefit from massive state financing, and past subsidies from military budgets. BNFL has inherited the technological 'know how' as well as the mills, conversion plants, fuel fabrication plants, waste storage installations and transport systems, at little or no cost.

Just what benefit this affords BNFL is illustrated by the difficulties being faced by those companies in the US that have tried to establish fuel fabrication and enrichment plants. Despite free access to



Final resting place for nuclear waste. Sites are being planned but nobody wants them.

government and military data, they have not been able to meet the huge capital costs involved and the long term nature of the investment has raised serious financial difficulties.

BNFL can on the one hand benefit from past investments and accumulated 'know how' and yet on the other hand can exclude items that occur on the debit side of the balance sheet. For example, the company has declared that nuclear waste generated before BNFL was constituted in 1971, is not their responsibility and that they will not pay for its disposal.

BNFL continues to receive substantial aid from the government. The Department of Energy is now authorised to grant £500m each year to BNFL. The government has also agreed to guarantee loans made to BNFL to the tune of £500m 'in respect of advance payments made by customers to BNFL'. In addition, BNFL benefits from the huge research costs which are at present met by the government in the field of nuclear energy.

Any accurate assessment of the true costs of BNFL's operations is thus not feasible. Suffice to say that the company's own submissions are likely to be a serious underestimate of the true cost of the processes involved in the fuel cycle.

This view is supported by the economist Colin Sweet, who has for a number of years been providing independent estimates of the cost of energy provision in the UK. At the Windscale enquiry he provided figures which showed that the unit costs quoted by both the BNFL and the CEGB for nuclear power were between two and three times too low. An equally large discrepancy appears, Sweet alleges, with regard to the impact of reprocessing on final electricity costs. BNFL put it at around 8%. Sweet (and others) point to a figure three times greater than this. (*Fallout* p.42)

Profitable or not, BNFL is enmeshed in a network of international fuel consortia. BNFL is involved in a tripartite marketing organisation called United Reprocessors, together with a French company. It is also connected to Dutch and German companies via Urenco, the company developing the centrifugal enrichment process.

Uncertainties

It is United Reprocessors, with its associated shipping companies, that are jointly responsible for the Japanese reprocessing contracts which provided the financial justification for the Windscale expansion. Without these international links, and the foreign contracts, the operations of BNFL would be even shakier in financial terms than they already are.

Great play is made of technological breakthroughs, and export orders receive wide publicity, but the growing commercial uncertainty of these operations is glossed over.

The Urenco operation for example represents a huge commitment of capital. Over the next ten years the three partners will have invested almost £1billion. Production of an initial 200 tonnes of enriched uranium at each plant is scheduled to rise to 700 tonnes at Capenhurst and 1,400 tonnes at Almelo (Holland) by 1982.

'Contracts for this entire output have already been signed' crowed Urenco in 1976. But there are difficulties. The £1,000million worth of contracts that Urenco claims are mostly from the interested parties. The actual value of the contracts may be much less. Ten of Urenco's twenty 'firm contracts' are from the German electric utilities and have clauses allowing postponement if the enrichment is not needed.

Following a general fall in demand, many energy companies already wish to postpone their contracts for three years or more. Urenco's planned capacity has already been delayed by two years, and Capenhurst is now offering to store enriched uranium until it is needed.

This predicament is exacerbated by the existence of other enrichment facilities in Europe. Urenco's main competitor is EURODIF – mainly French. France already has a large diffusion complex at Pierrelatte, and has plans to build a gas centrifuge facility as well. Whatever the level of demand in the future, the scene is set for a glut of enriched uranium.

Just how formidable is EURODIF? While it is more expensive, considerable advantage derives from the fact that it supplies the three markets least perturbed by nuclear energy – France, Spain and Iran. Nor is Urenco likely to attract other potential customers in Europe. Belgium and Italy have recently joined EURODIF and are still stinging from an earlier exclusion from development in Urenco.

So future prospects for BNFL are not what they seem. There is the serious possibility of a vast oversupply of enriched uranium in the 1980s, and recent decisions that have been made by other countries will exacerbate this. In March 1978 it was reported that the German company Uranit plans to construct an enrichment facility at Gronau in Germany. Japan has also announced the setting up of a pilot centrifuge enrichment plant, and plans to have a fullscale one working within the next 12 years.

Whatever happens BNFL now has a vested interest in the growth of the nuclear industry worldwide. But despite the promises, is the current expansion of British Nuclear Fuels going to be another financial fiasco? The chances are greater than anyone cares to admit.

UNSAFE AT ANY PRICE

Popperfoto

The safety problem is central to the whole question of nuclear power. If it is safe, then the question of whether or not to use it becomes no more than a matter of economics. Despite all the machinations of accountants, whether or not nuclear electricity is economically competitive will eventually be determined. But what is the point of worrying about relative costings, if the technology is fundamentally dangerous, and exposes all those who live and work within hundreds of miles of a nuclear station to appalling risks.

This is the belief that has motivated strong anti-nuclear campaigns in countries as diverse as the US, Germany and France. That in turn has driven the nuclear corporations to turn to countries such as South Korea, Brazil and Iran, all renowned for the violence of their repression, for their future sales growth.

Secrecy

In Britain the safety questionmark hanging over the Pressurized Water Reactor (PWR) has so far proved sufficient to prevent its adoption for the UK nuclear programme, despite powerful corporate support. But, although Britain has an exceptionally high population density and hence a high relative exposure to any nuclear risk, it has nonetheless accepted a very large nuclear power programme. Does this mean that the British reactors are safe? And does it mean that we have, or should have, confidence in the authorities that are responsible for these matters?

Judging by the record the answer to both questions must be a very clear no. In the US, public pressure alone has ensured that information from the nuclear safety agency is open to scrutiny – adverse information can only be suppressed with difficulty. This has led to considerable effort and resources being devoted to safety research, including large scale simulations of possible danger situations. It has led to stringent criteria being applied to nuclear plant location, design and construction, stringent that is, compared to Britain. And it has provided the basis for preventing the building and operation of many nuclear plants in the US.

It is a far cry from the situation in Britain. Britain's nuclear establishment operates in secrecy that can only be justified if there is something to hide. Given that the safety authorities are supposed to safeguard the public interest, why is the public denied access to basic information? The main bodies involved are the Nuclear Installations Inspectorate (NII) and the National Radiological Protection Board (NRPB). Many of their officials are bound by the Official Secrets Acts. Their caution about publishing information on policy and practice has been compounded by the widespread official belief that the public should not be 'overloaded' with information about nuclear safety held to be 'confusing'.

The NRPB, which sets radiation standards, is a closed, politically unaccountable body. It plays a major role in reassuring the public about health dangers from radioactive discharges. But many of the standards it has set are substantially lower than the equivalents set by the US Environmental Protection Agency. The exclusive and private way in which the NRPB's standards are arrived at, and the merits of the standards themselves, was one of the bones of contention at the Windscale inquiry.

Such challenges have not yet been effectively raised over the work of the NII. It is responsible for ensuring that the nuclear power plants are safe. At least, that is the theory. The way in which the NII works tends to confirm one's worst fears about the safety of the British nuclear power stations, particularly the AGRs.

Responsibility?

The Nuclear Installations Act (1965) says that nuclear power stations, other than those operated by the Atomic Energy Authority (AEA) or by government departments, must be licensed. The owner of the station is responsible for the safe siting, design, construction, operation and maintenance of the plant at all times. No regulations have been made relating to safety criteria or standards under the Act and the NII has not issued standards or codes of practice for nuclear plant. In essence, what happens is that the licensees issue their own specifications which they then submit to the NII. The NII then assesses them according to international safety standards and seeks modification where necessary.

Not even these requirements apply to the plants run by the AEA. These are prototype and development reactors, and the authority considers itself to have more expert knowledge than the NII on the questions of safety and reliability. As a result there is no outside body that assesses the safety of the AEA's work on prototypes and weapons.

If the experts are within the AEA itself, why doesn't the AEA deal with all safety issues? The industry's answer is that the NII was set up to be at arms length from the rest of the industry, which the AEA is not. But it is only permitted to wield its authority over the 'commercial' stations.

The NII states that the primary safety assessment is carried out before construction of a plant is permitted. This is a very difficult and complex task, mixing complicated engineering and structural calculations with computations of the probability of different kinds of accidents or failures occurring. The target is to assess the probable scale of such incidents and the deaths, injury and property destruction they would involved. It is all highly theoretical, and open to major errors of both computation and interpretation. Yet these calculations are not publicly available for checking. And some of them have been proved entirely wrong. In the case of the AGRs. for instance, no one had realised the vibration and corrosion problems that hot gases would cause, travelling at near supersonic speeds and under high pressures through metal ducts.

Design Faults

Even assuming the safety assessment is correct and the design falls within it, the next problem is to ensure that the plant is constructed as designed. Even in ideal conditions it is impossible to manufacture a product as complicated as a nuclear power station perfectly. The AGRs were built under very bad conditions. A large proportion of the work was done on site. On top of this, they underwent considerable modification throughout the construction period, leading to inevitable confusion and, doubtless, the taking of short cuts. Design faults meant that the welders for parts of Dungeness B had to be very small to get into the confined spaces they had to work in. Did the NII's inspectors manage to fit in? At the same time labour relations on the AGR site have been bad. Altogether, hardly the conditions in which to expect exacting quality control standards to be rigorously and successfully applied.

When Hinckley Point B was within nine days of producing electricity an ominous rattling started in the reactor. 'It was deduced that a big valve deep inside the reactor was vibrating violently as it tried to stem the gush of hot gases. But which of the 308 'gags' in the reactor was it? "The enormity of the problem only dawned slowly," admits one engineer. Over a period of months they withdrew more and more of the gags. The damage was frightful. The tough stainless steelwork was scoured, bent and battered; in some cases pounds of steel had been chewed completely away.' (*Financial Times* 23.2.76)

Differing 'Standards'

We don't know what criteria are used for the primary safety assessments of the AGRs. Were separate ones made for each of the three different AGR designs? We don't know how effectively the safety requirements were enforced on site during the construction of the plants. And we have no idea what chance there is that the NII itself has made errors in assessing the safety of the AGRs.

What we do know, and the NII admits, is that much of the detailed design of components takes place over a period of years after the primary safety assessment is carried out. By the time this and the major design modifications that have occurred in the AGR programme are compounded, the whole safety profile of the plant may have changed. But there is no overall reassessment at any stage: the reassessments are made only on the particular modification or component design change.

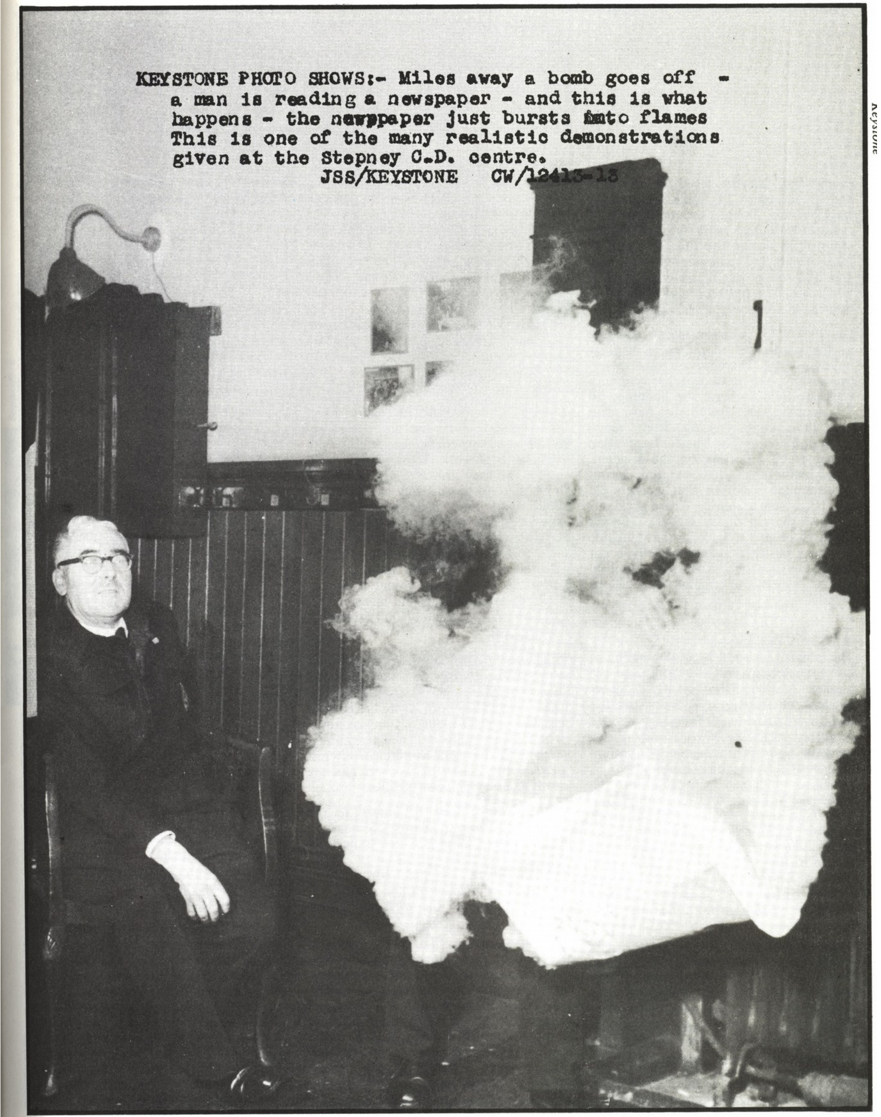
As recently as January 1978 the British government announced that it would order two more AGRs. It effectively ruled out the American PWR reactors for the time being on safety grounds. The AGR should have been ruled out for the same reasons. Firstly, if British standards had been set as high as those in the US, it is extremely doubtful whether the AGR programme would have gone ahead in its present form. Secondly, there has been no large-scale testing of the AGR compared with the work that has been carried out in the US on the PWR. Both are potentially dangerous, of course, in that they are attempts to harness the energy of a nuclear explosion while keeping it under control. But while the particular danger of the PWR lies in the inherent weakness of the pressure vessel design, that of the AGR lies in the inherent difficulties of the on-site construction and weakness of the British safety agencies.

Accidents

There have been numerous instances of faults, failures and accidents which have occurred in Britain's nuclear plants. The most recent at Windscale led to the closure of the whole reprocessing plant. A build up of hydrogen in a silo used to store the alloy cans stripped from spent Magnox fuel gave rise to fears of an explosion. Radioactivity was released and the plant was closed. At the same time, at Hunterston B, a power station bedevilled by design and safety faults, a 'low level' radioactive waste pipeline sprang a leak.

Similar incidents are also common place. In 1975 there was a spontaneous ignition of uranium hydride. A burning element was put into the 'fuel pond' and there was a release of radioactivity into the water and the atmosphere. In 1976, loss of coolant occurred as a reactor was shut down. Working areas were contaminated and damage was done to wiring 'associated with safety'. In another reactor, close-down was not correctly carried out and 14 tons of carbon dioxide was released. The pile cap was contaminated.

Two incidents at Windscale are stark reminders of how critical many of the operations carried out in nuclear plants are. In October 1957, a fuel rod in the Windscale plutonium production reactor



KEYSTONE PHOTO SHOWS:- Miles away a bomb goes off -
a man is reading a newspaper - and this is what
happens - the newppaper just bursts into flames
This is one of the many realistic demonstrations
given at the Stepney C.D. centre.
JSS/KEYSTONE CW/12413-13

Keystone

caught fire. The fire raged for four days and at one point 11 tonnes of uranium were burning. Twenty thousand curies of radioactive iodine were released to the atmosphere during the fire. Two million litres of milk had to be poured away in an area 500 square kilometres downwind of Windscale. The full report of the inquiry into the incident was never published.

On 29.9.1973 radiation alarms sounded in the oxide fuel reprocessing plant in building B204. There was no pre-arranged evacuation plan, or loudspeaker system to warn workers to leave the building. All 35 people were found to have skin and lung contamination from radioactive ruthenium. The Nuclear Installation Inspectorate, reporting on the accident, noted with regret that radiation alarms had sounded so often that workers did not take them seriously. These accidents are just the tip of the iceberg. The list could go on and it would still not include the near misses that undoubtedly occur and the accidents in the weapons establishments, which are treated as 'official secrets'.

The Penalty

The penalty incurred is contamination of the environment and the bodies of the workers in the nuclear plants. A recent incident at AWRE at Aldermaston has highlighted just how inadequate protective measures in the workplace are. Twelve workers were contaminated. Plutonium had built up in their lungs and this remained undetected because of the inadequacy of the monitoring equipment. **The fact that the new 'whole body monitor' cannot detect the most damaging materials, like plutonium, when lodged in the body, has led to widespread concern among workers in the nuclear industry who must trust management that effective monitoring and controls are in operation.**

The number of compensation cases arising from contamination is increasing. Despite the difficulties of proving that death from cancer or leukaemia was caused by radioactive contamination, BNFL has already been successfully sued by two widows of nuclear workers and eight cases are now outstanding.

So far, after two decades of nuclear power in Britain, a major nuclear catastrophe has been avoided. Should that give us confidence? The central question is what is the main concern of those who control the industry? Is it an absolute regard, above all else, for the health and safety of the workers within the plants and the wider population around them? Or is safety regarded rather as a problem that interferes with the main work of the industry but which, nevertheless, has to be dealt with at a minimum level to assuage public concern? The answer can best be seen in the light of the experiences of those working within the industry.

The management of British Nuclear Fuels Ltd (BNFL) gives the impression of concern and experience in dealing with the hazards of work. To an extent, this is correct, as they are certainly concerned about their image on safety to the general public, and they have had 30 years experience of handling radiation. But there are other hazards besides radiation, and a real concern about safety would be reflected in dealing with these as well. You only have to go round a nuclear plant to see that it is the image rather than the reality of safety that takes first place.

Much nuclear process work is little different from work in a petrochemical plant. There are long term risks such as cancer peculiar to both, as well as hazards common in most industries such as noise, oil mists and badly designed machinery. So there is the usual conflict of interest between the health of workers and the health of the companies' profits.

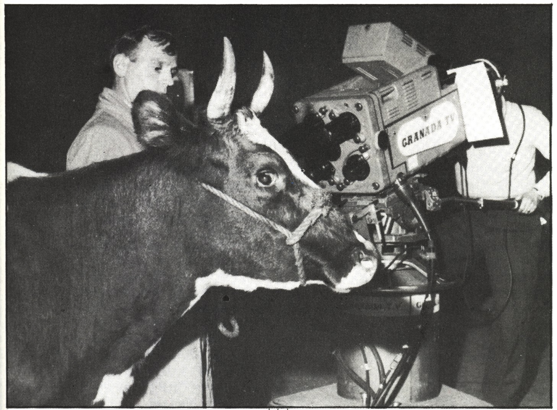
It doesn't take long to notice. In the power rooms and at almost all stages in the processing there is a deafening level of noise. In most places it is about 90dBA, which is the government's recommended maximum and which will cause one-tenth of the workers to lose 20% of their hearing over 15 years.

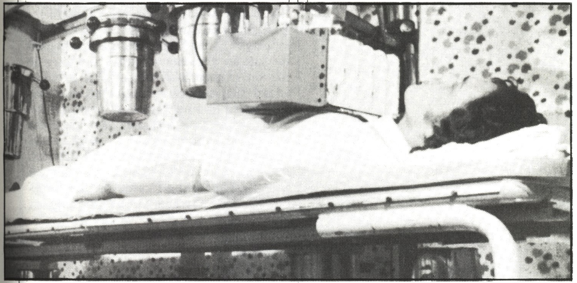
When it is above that level, does the management pull out its available technological resources to solve the problem? No. At Trawsfynnyd power station, they put bits of string around the areas and suggest you wear earplugs. The total cost of this piece of high technology is about 20p. Such is the measure of the real concern for workers' health. Many buildings contain noisy engines, forcing everybody to shout, wear earmuffs and suffer loss of hearing. Money goes on publicity, on printing posters, not on providing basic improvements on shielding and suppression.

Radiation effects can emerge immediately, or after a number of years. They can destroy the body, or injure the children of those affected. Depending on degree, radiation can destroy blood cells, stomach, intestine, and even the central nervous system. Smaller doses entail a longer sequence of biological consequences. Leukaemia may be induced five years or more after exposure: other cancers may not show up for twenty years. Every increase in radiation levels has its impact, even undetectable levels lead to accelerated aging, or 'radiating life shortening'. The most damaging materials, like plutonium are the most difficult to detect inside the body. Cities along the Ohio river, downstream from the nuclear reactor at Piqua, have shown increases in cancer rates of 20 to 50%.

Talking with the elected safety representatives, it soon becomes clear that they are concerned with a dozen and one different sorts of hazards. They have a job getting a machine that causes backache to be raised three inches off the ground, and they are worried about the fumes from solvent extraction. Elsewhere the machines are too close so they are trying to get them put further apart, and the rooms are so hot that several people keep getting headaches. They are annoyed that the protective clothing is uncomfortable, and that they are not getting very far with the fume extraction.

In one BNFL factory, where union representatives successfully forced readings to be made of uranium oxide dust, it was found that the readings were over the maximum. The management response? A clean-up, perhaps, or more exhaust ventilation, or a regular system of cleaning? No, workers had to wear respirators – or they were on a charge. In another factory the ore is purified by dripping nitric acid over revolving drums. It's a simple enough system to enclose,





Popperfoto

A radioactive cow contaminated after an accident at Windscale. All milk produced within 200 square miles of the power station had to be banned.

Whole body monitor. Its ineffectiveness in detecting radiation is causing concern.

but instead the nitric acid fumes escape into the workshop where they hang round until eventually being evacuated through Ventaxia fans 50 feet up in the roof.

Other safety representatives, recognising the conflict of interest over health and safety, feel that the precautions established for emergencies, fires or dangerous situations are alright on paper but useless in reality. There are criticality and fire alarms, but neither are much use if you cannot hear them above the noise.

Loopholes

Perhaps the biggest loophole in the safety procedures is that relating to 'contact areas'. These are designated areas where you have a high risk of radiation contamination. Only certain people can go in, and they have to change their clothes and have regular medical checks. Yet in one BNFL site, there are two contact areas – one on either side of the road. So instead of having to change every time you cross, there are a set of white tram lines painted across the road. It obviously saves a lot of time, but how about all the people going along the road? This may sound horrific, but these problems are quite everyday and mundane to the workers in the plants: so much so that they become acceptable after a while. In the past BNFL workers have accepted money for working in high temperatures, and for working in the glare of so much adverse publicity. But money is not enough when lives are at stake. Matters came to a head at Springfields, where the unions complained about dust levels in Building 26. Although they had complained about it for a long time, they were always reassured that there was no danger. Finally they were driven to strike action. Windscale revealed the real dangers of uranium oxide dust, and at last something was done to improve conditions – but not until after the workforce had been driven to resort to direct action.

BNFL's management has sophisticated techniques to make it appear that their safety organisation is adequate and vigilant. They have health centres and standards of all sorts. Every time there is a complaint, about dust, noise radiation or whatever, these standards are produced. They keep everyone arguing, although it is not clear on what they are based, or whether they are realistic. For instance, the radiation limits were set 12 years ago, and have not been reassessed despite new evidence that they are inadequate. Findings at the Portsmouth Naval Shipyard in New Hampshire revealed that 38.4% of all deaths were due to cancer – nearly twice the national average – despite working well within the international standards.

There are also safety committees and 'accident investigation procedures' to give the impression of concern. Yet the accident investigators are only 'to look into accidents and to find their cause and not to allocate blame', while the safety committees (known as tea and biscuit committees by many) do only what the management says it can afford.

Safety representatives, especially in this industry, need more power. For instance, they need to have external advisors on certain technical matters – but there is little hope that the authorities would clear the people they would want. Similarly with accident investigations, the Official Secrets Act provides a screen behind which to hide.

The nuclear establishment is concerned with its public image – not with the health and safety of its own workforce. The attitudes of BNFL management within its own plants undermines any confidence we may have in their public declarations. Nuclear plants present an appalling threat – and the authorities responsible for ensuring their safety cannot, with their secrecy and recorded inadequacies, be trusted.

TRUE TO TYPE

After GEC with its current shareholding of 30%, the balance of private-sector shares in the National Nuclear Corporation (NNC), now Britain's sole nuclear power plant design and construction company, is held by a consortium of companies known as British Nuclear Associates. Of these, Babcock & Wilcox has the largest shareholding and Northern Engineering Industries (the merged interests of Clarke Chapman and Reyrolle Parsons) has the second largest.

A study of these two companies shows clearly that whatever role the state casts them in, their instincts as profit-making concerns ensure that they follow what they consider to be their own best interests, to the detriment of the government organisations and at the taxpayers' expense.

Babcock & Wilcox has been involved in the nuclear industry since 1948. Their participation has included steam generating systems, large, complex pressure vessels, structural and other components from initial conceptual design through research and development to detailed design, manufacture, site construction and commissioning. Starting with the Atomic Energy Authority's (AEA) early pre-Calder Hall development, its activities have extended to the Magnox reactor, the Advanced Gas-Cooled Reactor (AGR), the High Temperature Reactor (HTR), the Liquid Fast Metal Breeder Reactor (LMFBR) and the Steam Generating Heavy Water Reactor (SGHWR). It has been responsible for many studies of Pressurised Water Reactor (PWR) nuclear ship propulsion systems. It was also heavily involved in the construction of the sodium-cooled PFR at Dounreay for the UKAEA, and has now been awarded a contract for the design and development of steam generators for the British Commercial Fast Reactor (CFR) programme.

In February 1978 Babcock & Wilcox headed a lobby of NNC shareholders (backed by electricity industry customers) demanding an end to GEC control. Basically, Babcock & Wilcox are in favour of AGRs and in opposition to GEC's preference for US designs. This is perfectly understandable within the logic of the market-place, as an American-based technology programme would give increasing advantages to GEC which already is in a very powerful market position. In demanding a reorganisation of the NNC structure, Babcock & Wilcox was also playing a tactical game. The proposed reorganisation would give no shareholder more than 15%. Meanwhile the company was in the process of attempting to merge its boiler-making interests with Northern Engineering. If the merger had gone through it would have created a powerful group which would inevitably vote together and be able to present a block to any GEC proposals with which it disagreed.

Jockeying for power and advantage are an essential part of private company mentality, and for this reason the NNC is constantly beset by internal conflicts. This conflict of private and public interests has been particularly evident in the failure of the government to bring about rationalisation of the boiler-making and turbine-generator industries into two single production companies.

In April 1978 Babcock & Wilcox, in order to facilitate the merger between its boiler-making interests and those of the NEI group reorganised itself into four divisions to become a holding company rather than a trading company. The original plan was for a tripartite company in which it, NEI and the National Enterprise Board (NEB) would have equal shares. This plan rapidly broke down however, due mainly to Babcock & Wilcox's desire to dominate the merged company through a majority shareholding. The revised scheme, after the exclusion of the NEB, gave Babcock & Wilcox 74% of the proposed company.

Merger Collapses

Having achieved this advantageous position, Babcock & Wilcox was incapable of refraining from the attempt to squeeze even greater advantages from its partner. As part of the 'rationalisation' following on merger, both firms felt it necessary that the main boiler-making plants should lose employees. Babcock & Wilcox from its position of strength tried to force NEI to accept the bulk of proposed redundancies at its Gateshead plant, while its own employees were kept on at its Renfrew plant. Both companies wanted to keep their plants functioning as potential recipients of further investments – with government subsidies – in order to take advantage of future nuclear contracts. Finally Babcock & Wilcox became too heavy handed for NEI and the merger fell through.

Despite the in-fighting and manoeuvring within the NNC the government agencies have become so involved with the private sector that they swallow the company line in its entirety. In September 1978 Babcock announced that they were embarking on a £70million modernisation at the Renfrew plant to handle 'expected new orders'.

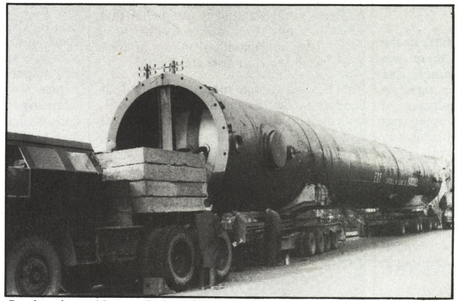
'Mr Bruce Millan, Secretary of State for Scotland, said during a visit to the Renfrew factory . . . that the Government wanted to sustain the heavy boiler industry in Britain' (*Financial Times* 5.9.78). Babcock added that such investment in rebuilding and re-equipping was essential if the industry was to survive, and that the starting date and speed of work would depend on the outcome of talks between the government, the CEGB and the two Scottish generating boards on the ordering of new power stations in the next 20 years.

Manoeuvre

A stated aim of the company was to 'increase their competitiveness in world markets'. It was admitted that the investment would result not in an increase, but in a loss of employees, and that by the time of completion the Renfrew re-organisation would cost well in excess of £100million. Babcock & Wilcox claimed that it would raise the money from its own capital resources, and also 'by asking the government for financial assistance over and above the basic 22.5% regional development grant which is automatically available.' (*Scotsman* 5.9.78) The overall operation would enable Babcock & Wilcox to bid for almost any type of power station work. More export orders were hoped for, as well as a substantial share of the expected increase in UK power station construction in the late 1980s and the 1990s.

Shortly after this announcement the company's half year figures showed a large growth in overseas demand and export orders, with overseas operations taking 67% of turnover. After excluding exceptional items which had boosted the 1977 figures, Babcock & Wilcox's half-year profits were up by over 40%.

NEI, the smaller of the two companies involved in the failed merger, also continues to benefit from government generosity despite the bitter internal struggles that the private sector has brought to the NNC. In mid September 1978 it was announced that the CEGB was prepared to accelerate its AGR programme in order to ensure a workload at NEI's Gateshead plant beyond the termination of its present contracts. (*Times* 14.9.78)



Profits from Nukes. Babcock and Wilcox heat exchanger onroute to French power station.

Keystone

NEI itself was formed as the result of private sector reaction against government plans – in this case for a rationalised turbogenerator industry. A merger was proposed in 1977 between the turbine operations of Reyrolle Parsons and GEC. Those in favour of the merger included the government, the NEB, GEC, and some Reyrolle Parsons board members.

In this case also the merger plans collapsed because of the unequal size of the proposed participants. It was feared that GEC would force Reyrolle Parsons to accept the brunt of the inevitable redundancy programme that would accompany the merger. The top directors at Reyrolle Parsons were able to play on these fears to gain shop floor support for opposition to the merger. The directors also had other reasons for opposing it. Reyrolle Parsons was making money but running out of orders. A merger with GEC would ensure future contracts but shift power firmly in the direction of GEC.

The Reyrolle Directors decided that they would rather control their own merger plans – they already shared a chairman with Clarke Chapman in the body of Sir James Woodeson.

As a result the new grouping, Northern Engineering Industries (NEI) came into being in September 1977 with no government participation and with a continuation of the competition and conflicting interests which had been the government's motivation for pushing the GEC/Reyrolle Parsons merger in the first place.

It soon became obvious that that merger had never had a chance, and that what Sir James Woodeson – now the chairman of the NEI group – was really after was the ability to be more competitive in the market-place and also within the decision-making structures of the NNC. A month after the formation of NEI, the new company was going ahead with plans to take-over International Combustion Holdings (ICH). ICH was particularly important within the context of the nuclear industry. It had many overseas operations, and a number of licensing agreements with its US parent company, Combustion Engineering. Combustion Engineering, in its turn, had nuclear reactor capabilities. In effect the takeover was NEI's entry to US technology which could increase its competitive position with GEC.

Success

By December 1977 NEI had won the struggle to take-over ICH. In January 1978 an agreement was signed for the purchase of Baldwin and Francis, a mining-switchgear manufacturer, and the next month a major reorganisation created NEI Overseas, NEI Projects, and NEI Power Engineering. By April 1978, the first annual report showed a pretax profit of £25.16million compared with the joint (Reyrolle Parsons and Clarke-Chapman) figures of £22.11million the previous year.

Corridors of Power

UK power generation currently represents about 15% of NEI turnover. The nuclear element of this is even smaller. What is important for NEI, as it is for the other members of BNA, is that it has an official involvement in a status industry with a high level of government subsidy. This involvement makes even more close-knit the interconnecting relationships between private and public individuals and organisations which give preferential treatment at tax-payers expense to certain companies, and allows these companies to influence public decision-making whilst remaining free from public accountability.

Sir James Woodeson is constantly able to use his contacts within the state structure to further his company's interests. As chairman of NEI he controls 10% of the NNC; he is also a director of the British Steel Corporation; as a representative of the UK power engineering industry he accompanied Edmund Dell, Secretary of Trade, to China where he was in a strong position to tender for a £75million fertilizer plant on behalf of his company. Yet it is a one-way relationship. The government promises to bring forward its AGR programme in order to keep the Gateshead plant in operation, yet the real interests of the company are in lucrative overseas operations and contracts.

The profit-making efficiency of companies like NEI, Babcock & Wilcox, GEC, Taylor Woodrow etc is enhanced by the publicly funded nuclear contracts and aid they receive. At the same time, the incredible inefficiency of the public bodies in which they are involved is attributable in part to their self-interest.

THE URANIUM FIX

The nuclear industry has, in the past, argued for nuclear power on the grounds that uranium is a cheap fuel. It is now shifting towards arguing for breeder reactors, on the grounds that uranium is scarce and is becoming expensive.

What is certainly true is that the price of uranium, which remained more or less static at around $8 a pound in the 1950s and 1960s, and actually fell to $5 a pound by 1971, has risen dramatically. It now stands at about $40 a pound on the spot market. Is this because uranium was in short supply? No. A US Congress committee states categorically that annual demand over this period was 26,000 tonnes, while annual world output was about 30,000 tonnes.

So what caused this rise of 800% in the price of nuclear fuel when there was plenty of surplus uranium around? The answer is simple. There was a cartel in existence, in which the producers of uranium fixed the price and doled out contracts amongst themselves. In this way they guaranteed themselves a profit. "The actual problem was to work out a method for selling only half or even less of the available production, with a prospect of having a higher cash flow than if a much higher production was sold." So said Mr Taranger of URANEX, the French uranium mining company at a meeting in Paris in 1972.

Orderly Market

The nuclear lobby denies that the cartel is responsible for the high price of uranium. They claim that the price of uranium was bound to rise when oil prices were increased by the OPEC states in 1974. This argument has been demolished by Paul Joskow, an American economist, writing in *The Journal of Legal Studies.* In a masterly analysis, written before full details of the cartel were available, he argues that the oil price rises cannot explain the increase in uranium prices, because other events have led to a reduction in expected uranium requirements. Since 1970, expectations of the amount of energy that nuclear stations will provide have actually fallen despite the oil crisis. Joskow concludes 'it is at least arguable that these prices have resulted from cartel behaviour rather than a short run market disequilibrium.'

Table 1: Crystal Ballgazing

	Forecast US nuclear capacity ('000MW) in:	
	1985	*1995*
1970 AEC Forecast	**300**	**–**
1975 ERDA ”	**160-245**	**445-790**
1976 ERDA ”	**145**	**370**

Other people have been prepared to go beyond that cautious academic judgement. Mr Landes, Chairman of the New York Assembly Committee on Corporations said: 'We believe that the cartel has set in motion price increases which put in doubt whether nuclear energy will continue to be a low cost energy source. In New York State, it is our belief that price increases set in motion by the cartel could cost consumers $1billion in New York alone between now and 1980.'

The first hints that the cartel existed, at least as far as the public was concerned, occurred in 1976. Documents surfaced which revealed the arrangements being made by the uranium producers. These documents were given to the US government and an investigation was initiated by a House of Representatives Subcommittee.

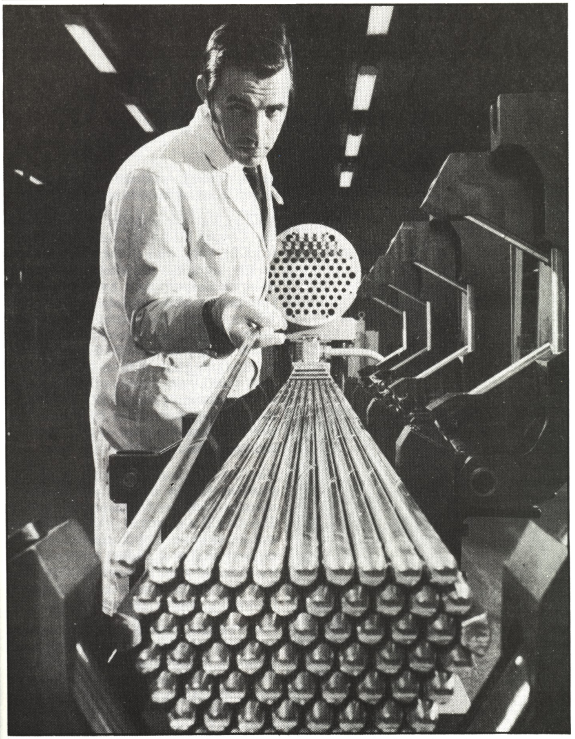
The investigation revealed that the cartel was a sophisticated operation. It had a paid secretariat, a policy committee, an operating committee, a formal document governing its actions and a system of sanctions for those who would interfere with the cartel's view of an orderly market.

In 1971 the Canadian government had been approached by Rio Tinto-Zinc (RTZ) about forming a cartel to control uranium markets. At that time uranium was selling for about $5 a pound and threatened to go even lower. For a world demand of about 26,000 tons in 1971, there stood ready 100,000 tons of supply.

In 1972 secret meetings were held in Paris and Johannesburg between uranium producers from Canada, Australia, France, South Africa and RTZ. These meetings fixed prices, rigged bids and allocated markets. In order to create the appearance of competition, bids to purchasing companies were rigged with precision. One company would give a prearranged bid, and then the designated follower would give a slightly lower price.

The House of Representatives has published a number of documents on the cartel, and the minutes of an operating committee meeting in Cannes in 1972 indicate how the cartel operated. 'In the absence of buyer decisions in Sweden and Germany, it was recognised that

RTZ Chief Executive Alistair Frame (left) with Chairman Sir Mark Turner.



Manufacture of fuel at Springfields.

Keystone

there was considerable difficulty in deciding who should be the lead bidders in the cases of Yugoslavia and Taiwan . . . There was a further understanding that if the Australians do get the Taiwan business, the 1975 delivery portions will if possible go to NUFCOR (the South African uranium producer).' (Page 318, Vol.2 International Uranium Cartel)

Lion's Share

It is clear from the minutes of other meetings in 1972 that the agreement was intended to last into the 1980s. The Australian uranium group for example was already, back in 1972, bargaining about its allocation for new production in 1978 to 1980, and uranium they are now trying to sell to the UK may well be part of this allocation.

The people who made the most money out of the uranium cartel were the directors and shareholders of RTZ. RTZ is the one manufacturer in the cartel which operates in all the areas of production covered by the cartel. The cartel arranged that RTZ's share of the market between 1972 and 1977 would be 4%. In fact it turned out to be 24.4%, the main losers being Australia and the French organisation Uranex.

RTZ is very concerned with maintaining its cash flow, because of the heavy debts it incurs in financing its operations. This is precisely what the cartel was meant to do. Without a large rise in the price of uranium, RTZ's Rossing mine in Namibia, mainly debt-financed, would never have proved economic. It is very unlikely that the whole truth about RTZ's role will ever be known.

The largest reactor manufacturer in the world, Westinghouse, had sold its reactors partly on the basis of contracting to supply uranium as well. Assuming that prices would remain fairly stable, they contracted to supply large quantities of uranium they did not actually have, at a fixed price. When the price of uranium started to rocket Westinghouse had to cancel many of these contracts.

The energy companies sued Westinghouse as a result. In its defence, Westinghouse claimed that it was unable to supply the uranium at the price in its contracts because of the operations of the cartel. To meet the claims would cost Westinghouse $2billion.

Westinghouse tried to make RTZ and its directors give evidence to support its case. Not unnaturally, the directors of RTZ were totally opposed to this. But, in a High Court hearing in London in 1977 to decide if the US court could demand to see RTZ documents and take evidence from the directors, RTZ lost the case. Taking the case to the UK Court of Appeal, RTZ again lost. The UK Court ruled that RTZ had to obey the US court.

Immunity

As a result, the RTZ directors appeared before the US judge in the American Embassy in London. They immediately claimed the 5th Amendment and refused to give evidence on the ground that they might incriminate themselves. The US court then granted them immunity from prosecution, which meant they were no longer protected by the 5th Amendment.

RTZ then tried another tack. This time they claimed that they could not give evidence because they might incriminate themselves under the EEC treaty against restrictive practices. They had to go to the House of Lords, and it was at this stage that the UK government revealed their interest in protecting RTZ. The Attorney General, Sir Sam Silkin, and the Solicitor General, Peter Archer QC, gave evidence. During the hearing, which had been hastily arranged for RTZ, Archer stated: 'Within the last week, the Foreign and Commonwealth Office has received representations from certain governments raising questions relating to this action', and, even more sinister, he added: 'I have been severely warned that I should not disclose in public all the facts I know.'

Needless to say, the House of Lords got the 'line' right when they delivered their judgement in December 1977. Every single judgement was in favour of RTZ, defending their right to maintain secrecy.

The cover-up was successful. The US Grand Jury investigating the breach of the Anti Trust Laws did not bring charges against RTZ although Gulf Oil, a US company alleged to be a member of the cartel, was cited for conspiracy.

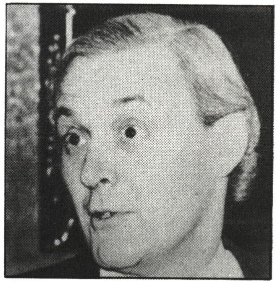
No Knowledge

Does the cartel still exist? It is alleged that it was wound up in 1975, but meetings which took place in 1973 suggest that preparations were already under way to form other bodies. The eighth session of the cartel operating committee, held in London in 1973, contained the following reference: 'XV.–Uranium Institute. RTZ and Canada will study the possible conditions in which such an institute might function in the UK and Canada. The Australians will prepare a draft constitution.' (Page 619, Vol.1 *Uranium Cartel Hearings*).

The Uranium Institute was set up in London in 1975. Housed in a prestigious office block in central London, its Director is Terry Price, an ex-civil servant who worked for the AEA, the Ministry of Defence, and then the Ministry of Transport. Once the Uranium Institute was set up, there was only one more meeting of the cartel. Needless to say, RTZ personnel play a prominent role in the activities of the Institute which organises seminars and meetings of many uranium producers around the world. Fears of anti-trust legislation still prevent any US producers from applying for membership of the Institute. Of course the Institute would deny any allegations that it was a public facade for the continuing operation of a cartel.

How did the British Government know of the operations of the cartel, and how happy were they to go along with RTZ's attempt to raise its profits? The directors of RTZ read like a political Who's Who, with Lord Byers, Lord Shackleton and Lord Carrington representing all major political parties in Parliament.

Anthony Wedgwood Benn has said, 'To be perfectly frank I had no awareness there was a uranium cartel until I read in the paper that the American Congress was investigating it. The concept of a uranium cartel was not brought to my attention except by my reading the paper and hearing that an enquiry was being set in hand.'



Yet knowledge of the cartel seems to have been widespread since 1972. The EEC Commission certainly knew of its existence. Lord Denning, the Appeal Court Judge, has said that there is evidence that the European Commission in Brussels knew all about the cartel almost from the beginning. On 15 September 1976 a member of the Commission stated: 'Since 1972 the Commission has followed with interest the actions of the uranium club.'

Terry Price of the Uranium Institute gave evidence at the US Embassy while RTZ was desperately trying to avoid it. He assured the American Judge that he only vaguely knew of the existence of the cartel and that Roy Wright, one time director of RTZ, had told him that it was wound up in 1975. He also said the existence of the cartel had been mentioned by John Waddams, Planning Officer of British Nuclear Fuels, over a lunch that they had together some years before. Off the record people in the industry are prepared to admit that its existence has been discussed for some years, though nobody is prepared to admit to actual knowledge of it.

RTZ is the sole supplier of uranium to the Central Electricity Generating Board (CEGB). Why, with all these rumours, did no one ask about the effects on the price of uranium purchased by this country? One person who certainly ought to have known about the cartel was Alistair Frame, Chief Executive of RTZ, who was also a member of the CEGB from 1974 to 1978. During his time at the CEGB he must surely have known of the operation of the uranium cartel. RTZ was after all the only supplier, and in 1976 the CEGB was told that the price of their uranium had been raised by 37%.

Whether the cartel still exists or not, the problem it was designed to deal with remains. There is still a surplus of uranium. The OECD states that 1977 production will be close to 30,000 tonnes, available capacity is almost 33,000 tonnes and the world requirement is about 23,000 tonnes. It is easy, with the spate of propaganda for the fast reactor, to forget this.

'The world's known low cost uranium resources amount to no more than 2 million tonnes of uranium . . . Further discoveries will, of course, be made, but continued reliance on thermal reactors seem likely to deplete low cost resources within a few decades and to lead to an upward trend in prices to match those of fossil fuels.' (Dr Marsham, AEA, October 1977)

Exaggeration

The OECD Nuclear Energy Agency and the International Atomic Energy Agency put forward a similar argument in their report on uranium resources published in December 1977. 'Clearly, thermal converters must in time be replaced by more advanced reactor systems that will conserve the uranium resources if nuclear power is to play a major role in supplying world energy needs in the longer term.' Yet nowhere do they back up these assertions. Instead, hidden in the text of the report is the fact that demand estimates for nuclear energy are continually being revised downwards, and reactor programmes are continually being delayed. 'Presently estimated uranium resources show that there is the ability to produce upwards of 90,000 tonnes a year by 1985 . . . if there is sufficient economic incentive and stability to provide the basis for orderly growth.'

All the indications are that there will be no demand for such production. The forecast for nuclear growth has again been revised downwards in the 1977 report. The previous world nuclear power forecast of 479-530,000MW for 1985 is now 277-368,000MW. The estimate for the year 2000 has been cut by half. They admit that the lowest estimates are the most likely. If the figures for estimated nuclear energy demand show anything, it is that forecasts tend to exaggerate wildly.

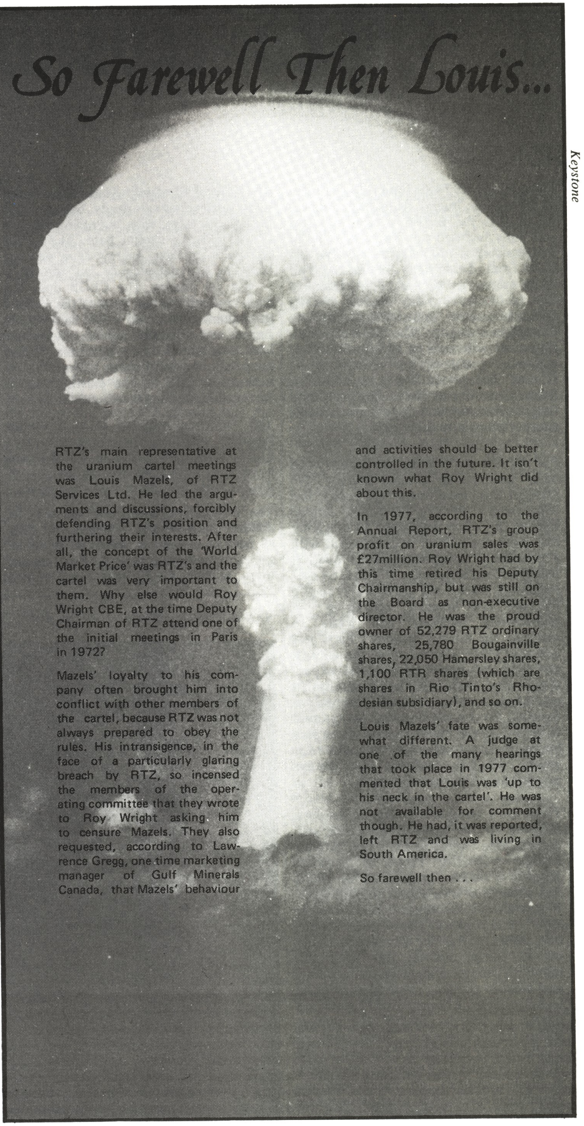
Other sources confirm that the future 'energy gap' is just a scare. The Australian Atomic Energy Commission has revised its estimates for world uranium requirements to 1985, reducing expected demand by 26%. This cut in expected demand represents more than the estimated total Australian sales in that period.

But the nuclear lobby has never let reality stand in its way. There might be a shortage of uranium by the year 2000, so enormous amounts of money must be spent on a fast breeder programme, and the sooner the better.

Other people are also looking forward to a shortage of uranium. The CEGB is currently financing uranium exploration ventures in Canada, Australia, Africa and the United States. According to the Department of Energy this arrangement, which started in 1976, was to ensure that there would be adequate supplies of uranium for the CEGB in the future. When it was pointed out that there would be no shortage, even in terms of known reserves, the reply was 'well that is the commercial risk you have to take.'

The question is, who is it takes the risk in the end? The mining company which has had its exploration financed by a state corporation? The corporation itself which enjoys being the monopoly supplier of an essential commodity? Or the consumer, who will pay through the nose for a massive fast breeder programme, an exploration programme, and the profits to encourage the mining company to produce the fuel?

So Farewell Then Louis...



Keystone

RTZ's main representative at the uranium cartel meetings was Louis Mazels, of RTZ Services Ltd. He led the arguments and discussions, forcibly defending RTZ's position and furthering their interests. After all, the concept of the 'World Market Price' was RTZ's and the cartel was very important to them. Why else would Roy Wright CBE, at the time Deputy Chairman of RTZ attend one of the initial meetings in Paris in 1972?

Mazels' loyalty to his company often brought him into conflict with other members of the cartel, because RTZ was not always prepared to obey the rules. His intransigence, in the face of a particularly glaring breach by RTZ, so incensed the members of the operating committee that they wrote to Roy Wright asking him to censure Mazels. They also requested, according to Lawrence Gregg, one time marketing manager of Gulf Minerals Canada, that Mazels' behaviour and activities should be better controlled in the future. It isn't known what Roy Wright did about this.

In 1977, according to the Annual Report, RTZ's group profit on uranium sales was £27million. Roy Wright had by this time retired his Deputy Chairmanship, but was still on the Board as non-executive director. He was the proud owner of 52,279 RTZ ordinary shares, 25,780 Bougainville shares, 22,050 Hamersley shares, 1,100 RTR shares (which are shares in Rio Tinto's Rhodesian subsidiary), and so on.

Louis Mazels' fate was somewhat different. A judge at one of the many hearings that took place in 1977 commented that Louis was 'up to his neck in the cartel'. He was not available for comment though. He had, it was reported, left RTZ and was living in South America.

So farewell then . . .

CONCLUSION

In September 1978 Sir John Hill, chairman of the Atomic Energy Authority, publicly stated that the British nuclear industry had 'fully justified the faith and hopes of the pioneers as the cheapest, cleanest and safest form of electricity generation.' This blithe statement was made in the face of the fact that by any known criteria Britain's nuclear industry has been an unmitigated disaster. The fact that such a statement was made at all is indicative of a central problem, the refusal of the Atomic Energy Authority to admit its failures, or even to discuss the possibility that maybe nuclear energy is not a viable form of electricity generation.

For the last thirty years the industry has been wrapped in official secrecy. No attempt has been made to justify this secretiveness. Behind the official smokescreens there has developed an unwieldy but powerful nuclear establishment with a ponderous momentum of its own. It will brook no arguments. It insists on ever increasing numbers of gas or water cooled reactors, fast breeders, processing and reprocessing facilities, and waste to maintain the nuclear 'balance'. Each new demand leads deeper into the morass of huge and unjustified capital expenditure. And as the snowball progresses an increasing number of 'safe' plants are revealed to be hazardous, background radiation levels build up, and there is a burgeoning mass of radioactive waste for which disposal methods are always promised for the year after next.

There are a number of different interests involved in the protection of this self-perpetuating monstrosity. The Atomic Energy Authority needs as large as possible a nuclear programme to ensure and expand its own power and influence. It has always surrounded itself with an aura of arrogance, answerable to no-one, seeing itself as the ultimate authority on all things nuclear. For years this monolith has used increasingly elaborate and elusive planning methodologies and techniques which have eroded Parliament's power or will to control the nuclear industry's development. Vast sums of public money have been devoured by the AEA to produce very expensive electricity in tiny quantities, an unsafe and uneconomical reactor, and totally inadequate waste reprocessing facilities.

The Central Electricity Generating Board likes nuclear power partly because it is capital intensive, thus increasing the size of the Board's capital base. The CEGB also sees nuclear energy as a way of lessening its dependence on the NCB – and on miners. The CEGB does not dare to admit the real costs of the current programmes. To do so would be to admit serious and expensive failures, and would lead to a halt in the programme. If this happened, the full burden of costs would have to be laid on the existing plants, further undermining their competitiveness.

The recycling industry is in a similar position. Without the move into fast breeders its own position will become more and more untenable as the cost of dealing with plutonium waste increases.

The private companies involved may be divided on particular strategies, but they all have an interest in seeing more public spending coming their way. For some of them, in fact, the alternative is a serious cut in profits. Clarke Chapman, for instance, has to be given the contract for the next AGR so that its boiler making business remains intact – there is just no other work to be won. NEI, the parent company, knows that it can demand the work by, in effect, pointing to the 'reality' of closure as the only alternative. But that means in turn that it can ask its own price, meaning guaranteed profits.

The nuclear programme so far has already meant a heavy swing in power generation spending away from the public sector to the private companies. Everyone directly concerned is happy with it: the AEA, steadily growing into a more solidly established monolith; the CEGB, with more and more capital tied up in power plants; and the private sector reaps the benefits of the CEGB's spending. But it is the role of the two state organisations, and the AEA in particular, that is crucial.

Nuclear power is the product of state research and development. It has needed

Anti-nuclear demonstrators battle with police in Germany.

Popperfoto

immense amounts of capital, for both the research and development and for the construction of the plants. And it needs considerable resources and economic leverage to be able to sell nuclear power in the international 'market'. That is why we see the close relationship between the state and the private companies in every country with a developed nuclear industry.

Given the scale and complexity of nuclear technology, the companies would not commit large sums of money to such a high risk area without major state participation. This is particularly true now, with enormous world-wide overcapacity. Instead, the state takes all the major risks and the companies manoeuvre to reap the benefits.

Because the nuclear stations are so capital intensive, there are much larger contracts to be won by the private sector from nuclear power than is the case with coal fuelled stations. With the coal stations, the larger part of the cost of generation goes to the NCB, a nationalised industry. With nuclear, it goes firstly to the private contractors and moneylenders, and then to the uranium suppliers (RTZ), and the reprocessing contractor BNFL. The latter is the only nationalised industry involved. Its turnover is less than one-fifteenth of the NCB's. It employs only 12,220 people, as against the NCB's 292,634.

Despite a crisis of overproduction on a world-wide scale, the private companies back up the AEA in calling for an enlarged programme based on fast breeder reactors. In 1975 the AEA produced forecasts which implied a need for 200 fast breeders to be built by the year 2020. A letter in the *Times* in June 1978 claimed that the fast breeder was the only solution to the growing energy gap, and called for rapid development of the fast breeder reactor programme for the 1980s and beyond. It was signed by, among others, Lord Nelson of Stafford, the chairman of GEC, and Kirby Laing, Deputy Chairman of the Laing Group.

Yet the fact remains that a world recession has cut the growth in energy consumption. It is increasingly difficult to foist unwanted complex nuclear technology on Third World countries. Back home, in the developed countries, there is no answer to the arguments of the safety objectors.

In Britain itself the situation is critical. No-one knows how long the AGRs will last even if they all reach completion. The corrosion produced by hot, pressurised gases may well make two unusable in a matter of years, and entail expensive repairs to the other three. In November 1978 there was yet another failure at an AGR plant, this time at Hunterston B. Radioactive waste from the nuclear power stations is having to be stored at the stations themselves as a frenzied effort is made to reprocess a waste backlog at Windscale, where new waste storage facilities are being built in a frantic effort to iron out bottlenecks in the reprocessing plant. Much of the waste now stored there is in a dangerous condition. On November 2nd 1978 the whole reprocessing plant was shut down following a build up of explosive gases in one of the waste silos. The plant will not reopen again until 'discussions' are concluded with the Nuclear Installations Inspectorate.

It is clearly time that a halt was called to the whole disastrous programme. The AEA should be disbanded, the AGR programme stopped, and the reprocessing now going on at Windscale should be completely investigated. The government must reveal what private arrangements it has with the uranium producers. Above all the records of the bodies concerned should be thrown open to public scrutiny.

We can be confident that the nuclear establishment will avoid at any cost a public debate on the question of nuclear power. The results of opening up the debate have already been seen in the USA, France and Germany, where the programme is under constant fierce public attack, in Austria, where the government was defeated in a referendum in November 1978, and in Sweden where the government was forced to resign in October 1978.

The industry cannot afford to have safety issues raised, nor can it afford to allow these objections to be coupled with the revelation that the whole nuclear programme is an economic disaster. We, for our part, cannot afford to allow this reality to go unchallenged or unexposed.

APPENDIX

Abbreviations

AEA:	Atomic Energy Authority
AEC:	Atomic Energy Commission (USA)
APC:	Atomic Power Construction Limited
BEEN:	Babcock-English Electric Nuclear Co.
BNDC:	British Nuclear Design and Construction Ltd.
BNFL:	British Nuclear Fuels Ltd.
CEGB:	Central Electricity Generating Board
EEC:	European Economic Community (Common Market)
ERDA:	Energy Research and Development Administration (USA)
FBR:	Fast Breeder Reactor
G-E:	General Electric (United States)
GEC:	General Electric Company (UK)
HTR:	High Temperature Reactor
NCB:	National Coal Board
NEI:	Northern Engineering Industries
NII:	Nuclear Installations Inspectorate
NNC:	National Nuclear Corporation
NPC:	Nuclear Power Company (operating wing of NNC)
NPRB:	National Radiological Protection Board
OECD:	Organisation for Economic Co-operation and Development
RTZ:	Rio Tinto Zinc
SSEB:	South of Scotland Electricity Board
TNPG:	The Nuclear Power Group
UPC:	United Power Company

Glossary

Uranium; is the mineral that forms the basis of all nuclear fuel. Some uranium is converted in thermal reactors (Magnox, AGR, LWR, CANDU) into plutonium, but larger proportions would be converted in intermediate and fast reactors.

Enriched Uranium; natural uranium contains 0.7% of fissile material. In enriched uranium this percentage has been increased.

Fuel Element; a unit of nuclear fuel in the form in which it is used in a reactor. Normally the fuel – uranium either natural or enriched – is enclosed in a can which protects it from corrosion by the coolant and keeps in the fission products (waste and plutonium).

Plutonium; an element produced by neutron irradiation of uranium. The isotope of plutonium Pn239 is a fissile material, and a potential nuclear fuel.

Isotope; are the different varieties of atoms which are chemically the same but differ in weight.

Kilowatt; a unit of power equal to 1.34 horse power.

Megawatt; 1000 Kilowatts equal to 1340 horse power.

Reprocessing; the processing of reactor fuel to recover the unused fissionable material, the uranium and plutonium, and to separate the waste fission products.

Tonne; is a metric ton and equals 1000kg or 0.984 tons.

Reactor Types

Magnox Reactors; use natural uranium clad in magnesium oxide, a graphite moderator, and carbon dioxide as coolant; they comprised the first British nuclear programme.

Advanced Gas-cooled Reactors (AGRs); similar to magnox reactors but use enriched uranium oxide fuel; they comprised the second British nuclear programme.

Light Water Reactors (LWRs); American designed, they are by far the most common: more than 80% of the world total. LWRs are so called because they use 'light' (ordinary) water as both coolant and moderator. They use enriched uranium as fuel; there are two main variations:

Pressurised Water Reactors (PWRs); pump water at up to 150 times atmospheric pressure through a heat exchanger and raise steam in a secondary circuit to drive the turbine generator.

Boiling Water Reactors (BWRs); boil the water directly in the core to produce steam which is piped to the turbines, which are coupled to an electric generator.

Steam Generated Heavy Water Reactors (SGHWR); uses heavy water as a moderator and also use water (light) to transfer the heat; the steam from the boiling coolant drives a turbine coupled to an electric generator.

Canadian Deuterium Uranium (CANDU); These are Deuterium (heavy water) moderated and natural uranium fuelled. They produce plutonium faster than most other designs.

All the above reactors are *thermal reactors* in which fast neutrons are slowed down by a moderator.

Fast Reactors, Fast Breeder Reactors; these do not normally use a moderator. Breeder reactors produce more fissile atoms than they burn: supposedly they will, when working, produce fuel as well as electricity.

The Consortia Chronology

– WHO THEY WERE AND WHAT THEY BUILT

1955

AEI and John Thompson formed the **Nuclear Energy Company (NEC)** and built the Berkeley Atomic Power Station (1956-62).

C.A. Parsons, A. Reyrolle, Sir Robert McAlpine, Clarke Chapman, Head Wrightson, Strachan & Henshaw, and Whessoe formed the **Nuclear Power Plant Co. (NPPC)** to construct Bradwell (1956-64) and Dungeness A (1960-66). This consortium also constructed the Latina reactor in Italy (1957-64).

GEC, and Simon Carves set up the **Atomic Energy Group (AEG)** and built Hunterston A (1956-64) and the Tokai Mura station in Japan (1959-66).

English Electric, Babcock and Wilcox and Taylor Woodrow formed the **Atomic Construction Co.** and built Hinkley Point A (1957-65), Sizewell (1961-66) and Wylfa (1964-71).

1956

Fairey, and International Combustion formed the **Atomic Power Construction Co** (APC) and four years later were awarded the contract for Trawsfynnyd power station (1960-65).

Vickers Armstrong, Rolls Royce and Foster Wheeler formed **Vickers Nuclear Engineering** (later Rolls Royce and Associates) to tender for contracts outside power stations involving nuclear technology.

1959

The Nuclear Power Co. (NPPC) joined the AEI-John Thompson consortium to form **The Nuclear Power Group.** This new grouping was responsible for the Magnox power station built at Oldbury (1962-67). Although the Nuclear Power Group favoured the Light Water Reactor technology the CEGB preferred the AGR system. Despite its preference the TNPG tendered and won the contracts for two AGR stations at Hinkley Point B and Hunterston B (1966-76).

The Atomic Power Construction Co. (APC) and the GEC-Simon Carves Group also merged and formed the **United Power Co. (UPC),** but GEC and Simon Carves quickly pulled out and it was the **Atomic Power Co.** alone that tendered for the fateful and as yet unfinished Dungeness B power station. APC was the only company to tender for this contract (1965-).

1967

English Electric and Babcock Wilcox restructured to form **Babcock-English Electric Nuclear**

(BEEN), began work on Hartlepool (AGR) in 1967. In 1969 the consortium was retitled the **British Nuclear Design and Construction Co. (BNDC)** and began a second AGR station at Heysham in 1970 (see below).

1969
A major restructuring of the nuclear energy industry. This followed the merger of the three electrical giants English Electric, AEI, and GEC under the name of GEC. The intention of the Labour government's Industrial Reorganisation Corporation in initiating these mergers was to encourage among other things some rationalisation of the nuclear energy industry. Further mergers with Reyrolle Parsons were projected but never realised.

The Nuclear Power Group (TNPG) was restructured with AEI pulling out and the AEA taking 20% of its shares. The IRC was also a shareholder until its dissolution.

British Nuclear Design and Construction (BNDC) was also restructured with GEC, the new electrical colossus, as a major participant. The AEA also took a 20% share, with the IRC also participating until it was dissolved.

The Atomic Power Construction Co (Fairey and ICL) had now got into such difficulties at Dungeness B that it collapsed and the contract reverted to the CEGB.

1973
Major restructure. Tory Govt. set up a single design and construction co – National Nuclear Corporation (NNC). Half the capital was provided by GEC who had overall management control of the operating company the Nuclear Power Co. (NPC).

NNC
GEC – 50%
NEA – 15%
BNA – 35% of which:
Babcock & Wilcox – 35%
NEI – 29%
McAlpine – 7%
Taylor Woodrow – 14%
Whessoe – 8.6%
Dickinson Robinson Group – 1.4%
Strachan & Henshaw – 5.7%

1976
GEC reduces its stake in NNC from 50% to 30%.

The AEA takes up the 20% to bring its total to 35%.

Atomic Energy Authority Establishments

Aldermaston: The Atomic Weapons Research Establishment Headquarters of the Weapons Group.

Amersham Radiochemical Centre
The production and marketing of radioisotopes.

Blacknest near Aldermaston
Centre for seismological research.

Bracknell Factory, Berkshire
Additional workshop capacity.

Capenhurst Works, Cheshire
Development work on uranium enrichment and the supply of enriched uranium.

Chapelcross Works, Dumfriesshire
Operation of production reactors, including the supply of electricity to the national grid and plutonium production.

Chatham
Part of the Analytical Chemistry Branch of Chemistry Division, AERE.

Culceth, Warrington: Reactor Materials Laboratories
Home of the Safety and Reliability Directorate.

Culham Laboratory, Abingdon, Berkshire
Research into plasma physics and controlled thermonuclear fusion.

Dounreay Experimental Reactor Establishment, Caithness
Centre for fast reactor development, including reprocessing and disposal of fuel waste.

Foulness, Essex
Weapons development. Studies of materials and structures under stress loading.

Harwell: Atomic Energy Research Establishment
Research into the non-military problems of atomic energy. Much of this work is done for industry.

London Office
Headquarters of the United Kingdom Atomic Energy Authority.

Orfordness, Suffolk
Environmental testing in the weapons field.

Risley, Warrington, Lancs
Northern Division HQ, Engineering Directorate, Technical Services and Planning Directorate as well as AEA laboratories.

Springfields Works and Laboratory, Salwick, Preston.
Development of fuels and fuel elements for thermal reactors.

Tadley, Basingstoke, Hants
Centre of the Southern Works Organisation.

Wantage Research Laboratory, Berks
An outstation of AERE which houses the Isotopes Research Division. Experimental irradiation of material with gamma rays.

Windscale and Calder Works and Laboratory: Sellafield, Cumberland
Operation of production reactors, including the supply of electricity to the national grid, plutonium production. Also chemical plants for the separation of plutonium, uranium, and fission products from irradiated fuels.

Winfrith, Dorset: Atomic Energy Establishment
Thermal and fast nuclear systems.

Nuclear Power Reactors in Britain

Name of plant	Location	Reactor type and number	Date of regular power op.	Operator	Main Contractor *Turnkey	CONTRACTORS					
						Reactor system	Reactor vessel	Core	Steam raising	Turbines	Civil works
Calder Hall	Cumberland	Magnox 4	8.56	BNFL	TWC, etc.	U.K.AEA	Whessoe	U.K.AEA	B & W	Parsons	TW
Chapelcross	Dumfriesshire	Magnox 4	3.59	BNFL	Mitchels, etc.	U.K.AEA	Whessoe	U.K.AEA	B & W	Parsons	TW
Berkeley	Gloucestershire	Magnox 2	11.62	CEGB	TNPG*	TNPG	JT	TNPG	JT	AEI	JL-BB
Bradwell	Essex	Magnox 2	11.62	CEGB	TNPG*	TNPG	Whessoe	TNPG	CC	Parsons	McAlpine
Windscale AGR	Cumberland	AGR 1	2.63	U.K.AEA	various	U.K.AEA	Whessoe	U.K.AEA	ICL	EE	U.K.AEA
Dounreay DFR(20)†	Thurso, Caithness	FBR 1	7.63	U.K.AEA	JT	U.K.AEA	JT	JT	JR	GEC	Whatlings
Hunterston A	Ayrshire	Magnox 2	2.64, 7.64	SSEB	GEC-SC*	GEC	MB	GEC	SC	GEC	Mowlem
Winfrith Dragon†	Dorset	HTR 1	10.64	Project	Project	Project	Mannesman	U.K.AEA	Wagner Biro	Reyrolle	Turriff
Trawsfynnyd	Wales	Magnox 2	2.65, 3.65	CEGB	APC*	APC	B & W	FEL	ICL	RW	NCC
Dungeness A	Kent	Magnox 2	1.66	CEGB	TNPG*	TNPG	Whessoe	TNPG	CC JT	Parsons	McAlpine
Sizewell A	Suffolk	Magnox 2	12.66	CEGB	EE-BW-TW*	EE-BW-TW	B & W	EE	B & W	EE	TWC
Hinkley Point A	Somerset	Magnox 2	5.65	CEGB	EE-BW-TW*	EE-BW-TW	B & W	EE	B & W	EE	TWC
Oldbury	Gloucestershire	Magnox 2	11.67, 4.68	CEGB	TNPG*	TNPG	McAlp/Whess	HW	JT/CC	AEI/Parsons	McAlpine
Winfrith SGHWR	Dorset	SGHWR 1	1.68	U.K.AEA	various	U.K.AEA	FEL/JT (37)	FEL/ICL	ICL	AEI/RPL	Turriff
Wylfa	Anglesey	Magnox 2	7.71	CEGB	EE-BW-TW	EE-BW-TW	TWC	EE	B & W	EE	TWC
Hinkley Point B.	Somerset	AGR 2	76, 77	CEGB	TNPG*	TNPG	McAlp/Whess	TNPG	CC/JT	AEI/Parsons	McAlpine
Dounreay PFR	Caithness	FBR 1	76	U.K.AEA	TNPG	U.K.AEA/TNPG	B & W	B & W	B & W	EE	TWC
Hunterston B	Ayrshire	AGR 2	39.61	CEGB	CEGB	TNPG	McAlp/Whess	TNPG	CC/JT	ICL/Parsons	McAlpine
Dungeness B	Kent	AGR 2	39.61	CEGB	CEGB	APC	Whessoe	FEL	ICL/B & W	Parsons	BB
Hartlepool	Co. Durham	AGR 2	81	CEGB	BNDC*	BNDC	TWC/B & W	GEC	B & W	GEC	TWC
Heysham	Lancashire	AGR 2	81	CEGB	BNDC*	BNDC	TWC/B & W	GEC	B & W	GEC	TWC
Sizewell B1-4	Suffolk	AGR 4	..	CEGB	NPC	NPC	..	..	..	..	..
Torness	East Lothian	AGR 2	.	SSEB	NPC	NPC	..	..	..	..	..

Companies in the Nuclear Industry

ANGLO GREAT LAKES, subsidiary of Northern Engineering.
Leading suppliers of nuclear grade graphite with much experience from the early nuclear power programme of the UK based on gas cooled reactors.

BABCOCK AND WILCOX (OPERATIONS) LTD, contracting division, London and Tipton design, engineering, erection and servicing of land and marine nuclear steam raising plant. Has a 19% trade investment in **Rolls Royce Associates Ltd** manufacturing marine nuclear propulsion units. Babcock and Wilcox (Operations) Ltd. is part of the Power and Process Engineering Group of Babcock and Wilcox Ltd.

BALFOUR BEATTY, subsidiary of BICC
Were the contractors for the civil works on the plants at; Dungeness B, and Berkeley (with John Laing & Son).

Balfour Beatty Construction Ltd has obtained an order from British Nuclear Fuels Ltd for work at the Windscale Calder Works (1977 Windscale enquiry).

BRITISH STEEL CORPORATION
The Special Steels Division produces a range of products for the UK and European nuclear power research plants, i.e. forged steel rotors, cast steel turbine housings, nuclear grade tube steel, high purity stainless steel plates, steel for turbine blading, creep resisting bolting steels and tube plates. The EXTENDED SURFACE TUBE COMPANY is a wholly owned subsidiary of the Tube Division and was formed in 1960 to supply finned tubes for the boilers of the UK gas cooled nuclear power stations.

CUNNINGTON & COOPER
Their components and mechanisms are in use in almost every nuclear power station and nuclear research installation in Britain.

They have supplied many in-pile components and sub-assembles, for example, temperature compensated restraint members for the graphite cores of Magnox reactors, and complex precision filter units for flow control of liquid sodium in fuel channels of fast reactors. Remotely controlled power driven equipment for handling fuel, fuel can de-splittering machines, vacuum vessels and glove boxes, flasks, skips, rigs, etc have also been supplied to various customers.

FAIREY ENGINEERING LTD
Work ranges from large fabrications for power reactors to the complete supply of research reactors, liquid waste disposal plant and the design and manufacture of complex experimental test loops.

A subsidiary company, Fairey Nuclear Ltd manufactures fuel cans and grids for gas cooled and sodium cooled reactors.

They produced the interlocking graphite block for the Dungeness B AGR. They also produced the complete fuel handling route on the twin AGR Dungeness station.

With regard to the SGHWR reactor system, FEL were major subcontractors to the Winfrith prototype reactor.

FEL is active in the field of research reactors and supplied the 5MW reactor to Chile. This reactor has completed its acceptance tests and is being operated by the Chilean Atomic Energy Commission.

Fairey Nuclear Ltd concentrates on the production of fuel element components in magnox, zirconium and stainless steel. It is a major supplier of fuel cans for the Magnox reactors, including those at Latina, and Tokai Mura. Stainless steel grids for AGR and the fast reactor PFR are also in current production.

FERRANTI
Alarm logging and post incident analysis are features of Ferranti systems which are used in the control of nuclear installations. The use of data logging and retrospective displays enable any systems incident to be examined along with the events leading up to it.

FLIGHT REFUELLING
Has developed and manufactured a remote television inspection system for Electricity Generating Boards in Britain for the purpose of routine and unscheduled inspection of reactors.

GEC-ELLIOT CONTROL VALVES
Manufacture the Fisher range of automatic control valves. There are factories at Rochester, Cowdenbeath and Cernay which have the capability and facilities to produce and supply pneumatically operated automatic control valves to meet nuclear standards.

GEC REACTOR EQUIPMENT LTD
Since 1955 GEC REL has been a major supplier of systems, plant and components for nuclear power stations; from the early Magnox stations through AGR, PWR the liquid metal cooled fast breeder reactors and the SGHWR.

An example of SGHWR is the Winfrith Heath reactor for which the company designed and supplied the main reactor and shutdown systems. It continues with major contracts for the CEGB nuclear power programme. And outside the UK the company was responsible for the design of the central control and radiation monitoring systems, specialised laboratories, production facilities, and hot cells for the Radioisotope Production and Research Centre in Romania. GEC also produces electro magnetic AC linear induction pumps for liquid metal. It also designed a personnel access airlock installed in the pressurised water reactor at Ko Ri in South Korea.

Finally, in 1976, **GEC Reactor Equipment** has provided a fuelling machine for the Italian Fast Breeder Reactor and is developing for the same a wide range of sodium instrumentation and equipment.

GEC CONSORTIA
A joint GEC-Romanian company has been set up to bring new business from Third World countries.

GEC TURBINE GENERATORS LTD
Apart from the extensive work commissioned by the UK Electricity generating and atomic energy agencies, GEC has carried out extensive nuclear contracts abroad. GEC has a licence to manufacture Westinghouse reactors turbines etc. This gives GEC experience in LWR technology as well as a realisation of the profits to be made by manufacturing 'American' reactors under licence. The export potential of this system has brought GEC down on the side of the growing argument that the UKs adopt the LWR/PWR system.

GEC Nuclear contracts outside the UK 1975-78
Two 1150MW turbine generators for USA
One 175MW unit for the Calgary Sundance station
Two 396MW units for the Righals station in Sweden

Two 200MW units at Hong Kong's Tsing Yi power station
One 375MW units for Wolsung Nuclear Power station from the Korean Electric Co.
Two 600MW turbine island and associated plant for the Ko Ri nuclear station in S. Korea, worth £50m.

GEC Power Transformers Ltd. Three of the largest series reactors to be manufactured outside Russia were built for the New South Wales power system.

GRAVATOM INDUSTRIES LTD, formerly Graviner Manufacturing Company Ltd.
Supplier of all nuclear services and a significant part of its output finds it way into the EEC, EFTA and world markets.

Assingments have included; a set of machines developed for the processing of fuel elements for PFR, CEGB underwater fuel element delugging machines, fuel element skip handlers, load/unload flasks; Waste management systems, plutonium postings systems, gamma irradiator design; Dismantling machines for fuel elements of the PEC reactor in Italy; Fuel element decanning machines; and casks and containers for the transport of radioactive materials.

A project completed a few years ago (1975) at Gosport is a plant designed to handle and wash loaded fuel element skips, the washing process being one phase in a fuel element reprocessing cycle.

HAYWARD TYLER, subsidiary of STONE PLATT INDUSTRIES.
Has been a principal supplier of primary circulating pumps to the nuclear industry since the earliest days of nuclear reactor development.

They have produced a glandless wet stator motor pump used on various reactor types, notably, boiling water reactors built by ASEA ATOM of Sweden, SGHWR for the UKAEA and Magnox reactors in the UK and Japan.

To meet the demanding reactor circulating requirements of water cooled reactors the Hayward Tyler controlled leakage pumps have been developed.

The Hayward Tyler pump test rig model is used for nuclear reactor coolant pump testing requiring a high flow, high pressure and high temperature. They have constructed this loop for testing the primary pumps for the GE-BWR at Caorso and are currently extending this loop to form a permanent test facility to accommodate the world's largest reactor coolant pumps.

HENRY WIGGIN & COMPANY LTD, subsidiary INTERNATIONAL NICKEL CO of Canada.
Produces high nickel alloys for nuclear engineering. It has an American associate Huntington Alloys Inc. Wiggin and Huntington heat and corrosion resisting alloys are widely used in steam generators, heat exchangers, reactor core and fuel assembly components in fast breeder and thermal reactors, and nuclear fuel processing and reprocessing plants.

HOPKINSONS, subsidiary of Hopkinson Holdings.
Manufactures valves and actuators for the early Magnox reactors in the UK, for the Winfrith Steam Generating Heavy Water reactor, for Candu reactors, PWRs, BWRs and Liquid Metal Fast Breeder Reactors.

In recent years a contribution has been made to the safety features of PWRs with the introduction of emergency main steam stop valves operated by the steam medium.

McALPINE
Have been the contractors on the civil works for the nuclear plants at; Bradwell, Dungeness A, Oldbury, Hinkley Point B, Hunterston B. They were the contractors for the reactor vessels at; Oldbury (together with Whessoe), Hinkley Point B (together with Whessoe), and at Hunterston B (together with Whessoe).

Has a share in British Nuclear Associates.

NORTHERN ENGINEERING INDUSTRIES LTD, formed Nov. 1977.
In 1977 Clarke Chapman and Reyrolle Parsons were merged. The new company NEI later acquired International Combustion. This merger represents a rationalisation of the heavy engineering industry following a serious fall off in UK business and the industries inability to compete in overseas markets. To meet the needs of the nuclear energy industry at home and abroad further mergers are projected but as yet no agreement has been reached: **Babcock Chapman,** integrating Clark Chapman, and Babcock Wilcox in the 'major utility boiler field', **GEC-Parsons,** integrating GECs and NEIs turbine generator business.

NEI subsidiaries
Clarke Chapman Power Engineering Ltd – large nuclear water tube boilers for power stations.

International Combustion Ltd – water tube boilers and heat recovery systems.

John Thompson Ltd -- nuclear reactor handling and fuelling equipment.

NEI Parsons Ltd – Turbine generators, condensing and feed heating plant for nuclear power stations.

Parsons turbine generators were recently installed in the new CANDU power stations at Pickering and Bruce in Canada.

SHELL TRANSPORT AND TRADING
No nuclear interests in the UK.

The General Atomic Co (US) is a 50/50 partnership between Shell and the Gulf Oil Corp. The company was set up to process nuclear fuel, construct nuclear reactors and carry out research in the nuclear field.

GACs attempts to purchase uranium and supply it to the US utilities has been unsuccessful and is now the subject of litigation.

GAC has built a HTR at Fort St Vrain for the Public Service Company of Colorado. GAC has constructed a fuel reprocessing plant at Barnwell in South Carolina (via Allied General Nuclear Services in which GAC has a 50% share), and has constructed a 'major' government funded facitity at San Diego, California, for research into thermo-nuclear fusion, which is nearing completion.

STRACHAN AND HENSHAW, subsidiary of DICKINSON ROBINSON Group.
Mechanical handling engineers.

The Dickinson Robinson Group has a 1.4% shareholding in British Nuclear Associates Ltd.

TAYLOR WOODROW
Have been the contractors on the civil works for the nuclear plants at Calder Hall, Chapelcross, Sizewell A, Hinkley Point A, Wylfa, Dounreay PFR, Hartlepool, Heysham, Sizewell B1-4, Torness, Sizewell C 1&2.

They were the contractors for the reactor vessels at; Wylfa, Hartlepool (together with B&W), Heysham (with B&W), Sizewell (with B&W), Torness (with B&W), and Sizewell C1&2 (with B&W).

They were also the contractors, together with English Electric and Babcock & Wilcox, for the reactor systems at Sizewell A, Hinkley Point A and Wylfa.

Has a share in British Nuclear Associates.

TUBE INVESTMENTS LTD
The TI Steel Tube Division produce tube for Reactor internals, Calandria shield tank assemblies; Pressure tube assemblies; Steam generators; Heat exchangers; Primary and auxilliary pipework circuits; Instrumentation; Fuel cladding; Fuel element components; Control rods; Turbine steam reheaters; Steam condensers; and Feedwater heaters.

TI is a major supplier of fuel cladding in stainless steel and magnesium alloy. Plain, stepped and finned stainless cladding and wrapper tubes are made for fast breeder reactors. Zircalloy pressure tubes were supplied by TI for the prototype British SGHWR.

TWENTIETH CENTURY ELECTRONIC LTD CENTRONIC
Its products are mainly reactor control and radiation detection equipment. They are used in almost every UK reactor and many European, US, and other world reactors. Its other products include Mass spectrometer leak detectors and residual gas analysers.

The Special projects Group of Centronic designed, manufactured and erected a boron isotope separation plant in the USA.

VICKERS NUCLEAR ENGINEERING DIVISION
Specialise in long, slim, tubular components for power reactors and irradiation rigs and loops for research purposes.

They have manufactured irradiation rigs for the UK AEA research programme on the SGHWR for UK power stations.

WEIR PUMPS LTD, subsidiary THE WEIR GROUP.
Has produced equipment for light water reactors and for the British SGHWR programme. Main product is the Weir TWL turbo-driven pump which can perform auxilliary feed, spray, and injection duties.

WHESSOE LTD
The company makes plant and control equipment for the nuclear power industry. The reactor vessels in nine of the power stations in the UK have been built by Whessoe, three in partnership with McAlpine.

Whessoe has a 6% shareholding in British Nuclear Associates.

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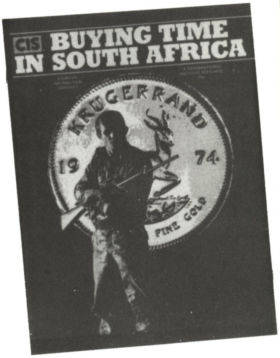

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